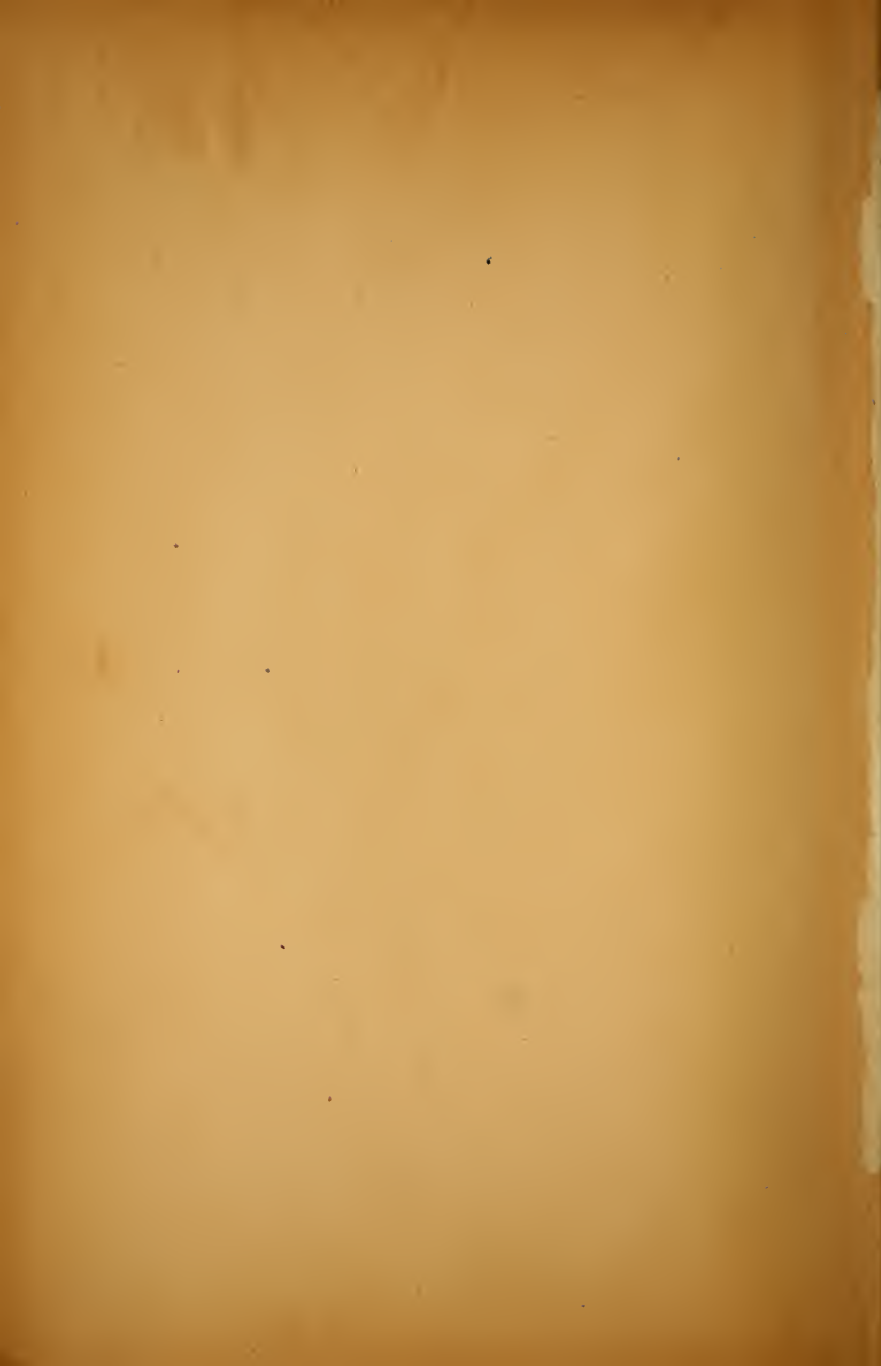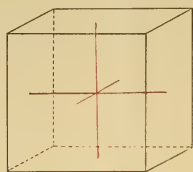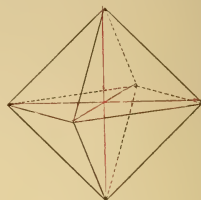# PLATE A.

FIG. 1.
Regular Cube.

FIG 2.
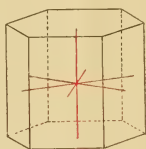Regular Octohedron.

FIG. 3.
Hexagonal Prism.
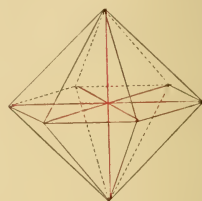
FIG. 4.
Double Hexahedral Pyramid.
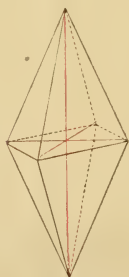
FIG. 5.
Quadratic Double Pyramid.
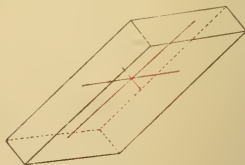
FIG. 6.
Triclinic Prism.

THE RED LINES REPRESENT THE AXES.

PLATE B.
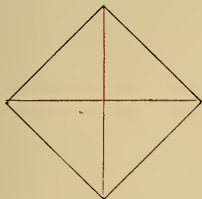
FIG. 7.

Axes connecting opposite angles.

FIG. 8.

Axes connecting opposite faces.
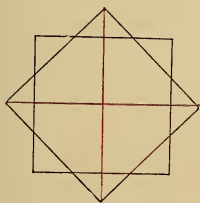
FIG. 9.

Represents Figures 7 and 8 laid upon each
other, causing intersection of faces,
and consequent truncation of
angles. (Figure 10.)
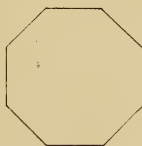
FIG. 10.

Represents the truncation of the angles,
resulting from the intersection
of faces. (Figure 9.)

**THE RED LINES REPRESENT AXES. [ONLY TWO OF THE THREE
AXES ARE SHOWN.] THE PLANES OF THE FACES
ARE REPRESENTED BY THE BLACK LINES.**

A COURSE

OF

HOME STUDY FOR PHARMACISTS

FIRST LESSONS

IN THE

STUDY OF PHARMACY.

BY

OSCAR OLDBERG, Phar. D.

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THE SCHOOL OF PHARMACY OF NORTHWESTERN UNIVERSITY.

WITH 150 ILLUSTRATIONS.

SECOND EDITION.

REVISED AND ENLARGED.

CHICAGO:
THE W. T. KEENER COMPANY.
1896.
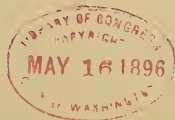
PREFACE TO THE SECOND EDITION.

The generous praise bestown upon the first edition of the HOME STUDY IN PHARMACY by teachers and students, press critics, and members of the State Boards of Pharmacy, is hereby gratefully acknowledged.

During over twenty years experience as a teacher of phar-maceutical students the author has been constantly called upon by beginners in the study of Pharmacy for advice as to what to read *first*. This book was prepared expressly for the use of such beginners. It is a pharmaceutical *first reader*—just such a book as the student of Pharmacy should read be-fore he reads any other text-books or treatises on the subjects which constitute the curriculum of a course of pharmaceutical study.

As indicated by its title, the HOME STUDY FOR YOUNG PHAR-MACISTS is designed to be read without aid or guidance from any teacher. The author has accordingly purposely repeated many of the more important statements in different ways and from different points of view, and has endeavored to adapt his language, definitions, descriptions, illustrations and gener-alizations to the receptivity of students having a fair common school education but no knowledge of chemistry and materia medica, and little or no knowledge of the nature, objects and general principles of scientific pharmacy.

The scope of the book is indicated in the table of contents.

Throughout the book there are many cross-references to help the student. At the same time the author has not hesitated to repeat wherever repetition seemed likely to be more convenient to the reader than to refer him to other portions of the book.

While Part I covers the whole field of Physics, only such portions as have a special interest to the student of pharmacy are treated at any length.

Part II covers theoretical chemistry quite sufficiently, and the experiments and examples given are such as the drug store affords. Chemical formulas, which are nearly always difficult to beginners, have been printed in two colors in the ten chapters devoted to the different classes of chemical compounds—the positive radical of the molecule in black, and the negative in red, so that the student can identify each at a glance.

Part III presents definitions of such general terms as medicines, drugs, chemicals, preparations, materia medica, pharmacology, pharmacognosy, pharmacy, pharmacopœia, pharmacodynamics, therapeutics, posology, etc. Chapter LXIII is devoted to a general review of the various classes of chemical constituents existing in plant drugs.

In studying of the chemicals in Part II and of the crude drugs in Part III, the student should familiarize himself with their appearance as found in the store, and compare the descriptions given in the book with the articles described. A cabinet of such drugs as are not always found in drug stores except in a comminuted condition, will be found useful to the student.

The symptoms of poisoning and customary antidotes are given under poisonous drugs.

As the author believes that every drug clerk ought to have at least some idea of what is meant by such common therapeutic terms as alteratives, antipyretics, hypnotics, carminatives, diaphoretics, etc., definitions of terms of this kind are given in Chapter LXXIV.

The aim of education is the healthy development, discipline and exercise of the faculties of observation and reasoning. Good education for pharmacy also includes the training of the hands to promptly and exactly obey the trained mind.

The road to the acquisition of knowledge and skill has its difficulties, but it also has its rewards. To the true student the study of pharmacy is brimful of interest and pleasure. There is fortunately no "royal road" or short cut. Full of genuine delight, the road to knowledge has no end. But the student must travel that road himself; no one else can do it for him.

No amount of home reading or study of any kind, with or without help, can alone fit any person for the practice of pharmacy. No courses of lecturers will alone accomplish the object. Not even laboratory courses can alone prove, sufficient. And no drug store training is alone adequate. All these several means must be utilized in an orderly way.

As it is highly important to the young men and women who propose to adopt the practice of pharmacy as their life work that they should have a clear idea of some of the conditions which directly and vitally affect success or failure in that pursuit, and as my advise is very frequently asked upon this point, I shall devote a few pages of this book to an "introductory" containing such information and suggestions as may prove helpful to those whose ambition it is to become worthy members of a most honorable and responsible scientific technical profession, and may at the same time, perhaps, deter others from entering upon a pursuit for which they are not adapted or which does not meet their expectations.

OSCAR OLDBERG.

December, 1895.

INTRODUCTORY.

CONDITIONS AND REQUIREMENTS GOVERNING THE PRACTICE OF PHARMACY.

The occupation of the apothecary is two-fold, for he is both a pharmacist and a merchant. The retail-druggist may be, and often is, an apothecary; but he may often be a mere merchant and not a pharmacist. In the majority of the retail drugstores of the present the "business" done consists of: firstly, the performance (intelligent or unintelligent) of special technical work such as constitutes *pharmacy*, and secondly, the buying and selling of miscellaneous *merchandise* including drugs, "patent medicines," toilet articles. stationery, and, generally, also cigars, soda-water, etc.

The legitimate pharmaceutical work done in any drugstore consists of identifying, testing, preparing, preserving, combining and dispensing medicines, and should also include chemical, microscopical and bacteriological examinations and other expert work such as is demanded by modern scientific medicine, since it is evident that the pharmacist is nothing if not the expert of the physician in these matters.

Pharmacy embraces all that part of the druggist's occupation which is in any sense scientific, technical or professional, and that is the only feature of the drug business which essentially distinguishes the pharmacist from ordinary merchants such as grocers, liquor dealers, tobacconists, etc.

Pharmacy is a scientific technical pursuit, and, therefore, its duties cannot be intelligently correctly, or safely performed by any person without sufficient special training. Hence *it is the only part of the retail drug business which is not subject to intense commercial competition.*

The mere buying and selling of miscellaneous merchandise by the retail druggist is no necessary part of the pharmacist's occupation. It is, and ever will be, subject to the same keen commercial competition that governs all mere retail vending, for it requires no special education except such mercantile training as is also necessary for the occupation of selling boots, books or bon bons.

Drugs and medicines of all kinds may be prepared, dispensed and sold by any person with or without a proper pharmaceutical education, just as the most highly educated physician and the most ignorant quack may both prescribe medicines. Under our defective laws this has been notoriously true in the past. The dry-goods store, the bazaar, or the grocery can sell patent medicines without let or hindrance. Retail druggists without proper special education in pharmacy have no more right to prepare or sell medicines than the grocer. Competent pharmacists alone can prepare and dispense medicines intelligently and properly.

In years past the retail drug business consisted mainly of pharmacy, and the mercantile feature was only an unavoidable but subordinate adjunct: to-day the commercial part of the business is in most cases its dominant feature and legitimate pharmacy is too frequently a mere incident. Retail drug business without any pharmacy connected with it is not at all uncommon; pharmacy combined with *much* merchandising is he order of the day; pharmacy with *less* merchandising is greatly to be preferred; but pharmacy *without* merchandising is the ideal pharmacy and is not only practicable but will surely come in the immediate future.

Young men and women who think of engaging in the retail drug business should, therefore, bear in mind that, if their object is simply *to earn a living* by any respectable pursuit, and if they prefer "keeping store" or "clerking in stores" to other employments, there are other kinds of store-keeping and

clerking quite as remunerative as those of the drug business,
and less arduous and dangerous. They should remember that
the practice of pharmacy is a specially risky and responsible
occupation, and that no person has any right to enter upon a
pursuit involving danger to human health and life unless he or
she is willing to acquire that thorough preparatory education
and training without which safety is impossible. The practice
of pharmacy without sufficient training for it is nothing less
than criminal. Intelligent and safe pharmacy without special
education is as impossible as seeing without eyes.

The Pharmacy of the Future.

By the " pharmacy of the future" I do not mean that ideal
practice of pharmacy which we may hope to attain to in the
course of generations, but the pharmacy which is already prac-
ticable to every well educated pharmacist. It is, indeed, al-
ready practiced in a limited way.

The advent of this new pharmacy does not involve any
radical or sudden disturbance in the commercial phase of the
retail drug business. It really means a gradual improvement
in the economic results of the business of every druggist who
is prepared to keep up with the march of progress. The re-
tail druggist of to-day may well be the pharmacist of the future
if he will but cultivate and extend the really professional part
of his occupation. This does not necessitate any immediate
diminution of the merchandising he is doing and which he may
find necessary or profitable; it simply means that he should
extend that part of his occupation which is peculiarly his own,
and can not be done by others, and which is on that account
the only service for which he is sure to receive a just return.

But the retail druggist of to-day, if he desires to retain the
pharmaceutical work he is doing, must either himself possess
the necessary training, or he must have in his establishment
those who are competent to perform all the duties of the ad-
vanced pharmacy.

The duties of the new pharmacy can not be performed by the untrained. These duties require a far better education than that possessed by a large majority of the persons at present employed in the retail drugstores.

IT IS OF THE UTMOST IMPORTANCE TO ALL PROSPECTIVE PHAR-MACISTS TO CONSIDER FULLY THE FACT THAT SUCCESS AND SATIS-FACTION IN THE PURSUIT OF PHARMACY HEREAFTER MUST, MORE THAN EVER BEFORE, DEPEND UPON THE EXTENT AND QUALITY OF THE EDUCATION OF THE PERSONS ENGAGED IN IT.

The uneducated man can never become a *pharmacist*, however successful he may be as a mere dealer in drugs, " patent medicines." cigars, soda water, etc.

" The pharmacist of the future must be fitted to decide correctly as to the genuineness, quality, purity and strength of medicines, to properly prepare and preserve them, to combine and dispense them accurately, and to apply for these purposes the best means which scientific training affords. He must understand and be able to perform all of the processes and methods of the Pharmacopœia.

" He must be practiced in analytical methods, quantitative as well as qualitative, and in the use of the microscope, and grounded in the scientific principles as well as in the practical operations of pharmaceutical work. He should be equally well prepared for the best professional service at the prescription table, to aid the physician by the reliable performance of all the chemical, microscopical and bacteriological examinations demanded by the modern science of medicine, and to act as public analyst especially for the protection of health.

The education necessary to that end can by no means be acquired in any drug store. It demands thorough courses in well equipped pharmaceutical schools, and, especially, extended laboratory courses in pharmacognosy, microscopy, chemistry and pharmacy.

The Pharmacy Laws.

The practice of pharmacy and the sale of medicines are fraught with danger to human health and life when engaged in by persons not possessing the necessary special knowledge and training, and all civilized countries have, therefore, passed laws to regulate the practice of pharmacy. The sole object of every pharmacy law is the protection of the public health, and it accomplishes that object by excluding from the practice of pharmacy all persons not properly fitted by education to be safely trusted with the performance of such important and responsible duties.

In the United States the pharmacy laws are enforced by the Boards of Pharmacy. The Boards of Pharmacy, and they alone, have the authority to decide who are qualified to engage in the practice of pharmacy. One of the important tests is an examination conducted by the Board. A definite period of shop training in the retail drug business is also required. All candidates found by the Board to be qualified are " registered" and licensed.

There are in some states two grades of pharmacists; in others three; in many only one class.

In a few states all graduates in pharmacy who have had four years experience in drug stores are registered without examination; but the American Pharmaceutical Association, composed of representative pharmacists of the country, has twice (in 1885 and in 1894) unanimously passed resolutions unequivocally favoring the rule that all candidates for registration as pharmacists or assistant pharmacists shall be examined by the Boards of Pharmacy, whether they be graduates or not, to determine their fitness. All of the best pharmaceutical schools or colleges are also opposed to registration without examination.

The American Pharmaceutical Association has, moreover twice (in 1894 an 1895) declared by unanimous vote, that no

person should be hereafter admitted to be examined for registration by the Board of Pharmacy without having first attended a good school of pharmacy.

It has further become a recognized principle that the candidate for registration must be possessed of a sufficient preliminary general education.

Much higher requirements have for many generations prevailed in most of the civilized countries of the world.

The tendency is certainly in the direction of less unsatisfactory educational standards for admission to the ranks of pharmacy in the future. Progress in this respect will necessarily be slow at first; but it will be steady and sure.

Boards of Pharmacy are most important bodies in the evolution of the pharmaceutical profession. They can not but recognize the trend of public opinion in reference to better, pharmaceutical education. They have the power of the respective state governments behind them in their efforts to enforce the pharmacy laws for the attainment of their only object—the promotion of the public welfare; and all friends of pharmacy are ready to uphold them in their efforts to discharge efficiently, faithfully, and wisely, their important trust

GENERAL QUALIFICATIONS FOR THE PRACTICE OF PHARMACY.

Persons ambitious to become good pharmacists must be intelligent, of good habits, orderly, systematic, and willing to perform every duty belonging to the occupation of the pharmacist and the routine of the retail drug store.

Innate integrity of purpose and conduct is indispensable.
Tact and good manners are essential qualifications.

Prospective pharmacists must be scrupulously neat and imbued with a natural and uncompromising aversion to dirt and disorder.

They must be animated by the desire to attain a high degree of professional knowledge, skill and usefulness in their

chosen calling, and should always continue to be guided by an earnest devotion to the science and art of pharmacy itself rather than by the selfish desire to secure pecuniary gain.

Poorly educated, dull, lazy, awkward, slovenly young men can never become competent or successful pharmacists.

The use of intoxicants, tobacco or other narcotics, or indulgence in any other bad habit or vice, must be regarded as liable to be attended with far more serious consequences in the occupation of pharmacy than in any other pursuit except in the practice of medicine.

The prospective pharmacist should have all his physical senses in sound order. A person who is color blind, or deaf, or who can not discern odors, or distinguish differences in taste, or whose sense of touch is deficient, is not a fit person to become a pharmacist.

Whoever wants to be a pharmacist should have perfect hands and fingers in order to be able to learn to perform the necessary manual details of pharmaceutical operations with neatness, precision and celerity.

The apprentice or drug clerk should respect the dignity of all useful labor, and must be willing at all times to do whatever duty he is competent to perform as soon as it presents itself, and especially should he be ever ready to contribute his full share toward the enforcement of strict cleanliness and order.

PRELIMINARY GENERAL EDUCATION.

No boy or girl under 16 years of age should ever enter a drug store for the purpose of learning the art of pharmacy, and no one should ever be permitted to begin the study of pharmacy either in a pharmaceutical school or in a drug store without having first acquired a preliminary general education *at least* equivalent to that (obtained in the public grammar

schools) required for *admission* to the high schools in our larger cities. A higher education is proportionately more valuable.

It is to be hoped, for the credit of pharmacy as well as for the better protection of the public welfare, that in the near future the pharmacy laws may be so amended as to prohibit the registration in the ranks of pharmacy of any person not possessing a general education at least equivalent to that required for *graduation* from the high schools. Several of the pharmaceutical schools of the United States now require a completed high school education or its equivalent for admission to a full two years' course such as is necessary to the accomplished pharmaceutical chemist of the future.

Arithmetic is one of the most important studies which the prospective pharmacist should master before he begins the study of pharmacy. He should on no account try to learn pharmacy unless he has a ready command of the use of common and decimal Fractions and of Percentage and Proportion. If he knows Algebra, too, so much the better.

A knowledge of Latin is very useful although by no means necessary. It is to be remembered, however, that the mental training incident to the acquisition of a good knowledge of Latin is of very great value—far more valuable than that knowledge itself.

A good knowledge of German, sufficient to enable the student to readily use German reference books on pharmacy and chemistry, and other related scientific works and journals, is extremely valuable to the pharmacist. German is, in fact, much more useful to the pharmacist than Latin.

The prospective student of pharmacy should have a fair knowledge of elementary structural botany. He should at least know organography. This knowledge he can acquire by studying any good elementary school text-book on botany such as, for instance, Gray's small work called First Lessons in Structural Botany.

A good, clean, regular, easily legible handwriting is also an exceedingly desirable, if not absolutely necessary, qualification.

Special Education In Pharmacy.

The Home Study in Pharmacy is of tried value as a course of preparatory reading. At the School of Pharmacy the difference between the student who has carefully read that book and the student who has not pursued any such preliminary reading is very marked.

The special education of pharmacists consists of two distinct kinds of training:—first, a sufficient course in a good pharmaceutical school; and second, at least two or three years good shop training, or active service or "experience" in a good pharmacy where real pharmaceutical work constitutes a part of the regular daily routine.

The object of the pharmaceutical school or college is to properly prepare the student for the performance of the work of pharmacy. The courses of instruction in such schools consist of lectures, recitations, lecture demonstrations, practice in the application of correct methods to the solution of pharmaceutical problems and in the performance of various kinds of work, the study of actual specimens of drugs and other materials, and laboratory courses in botany, pharmacognosy, chemistry, the preparation of pharmaceutical products, the examination and valuation of drugs and preparations, the problems and manipulations of the art of compounding medicines, etc. etc. The most important courses in the pharmaceutical schools or colleges are the laboratory courses.

Those who are ignorant of botany, pharmacognosy, chemistry and of true scientific pharmacy are necessarily incompetent to fully appreciate the value to the pharmacist of either of these sciences or of systematic special education for the practice of pharmacy. But it would seem to be reasonable to hope that intelligent young men and women should accept the

advise of any competent educated pharmacist, and especially the testimony of experienced pharmacists who are teachers in the pharmaceutical schools, any one of whom can demonstrate to them that pharmaceutical botany, microscopy, pharmacognosy, chemistry and a knowledge of the object, functions, and general principles of pharmacy are absolutely necessary to the intelligent performance of the practical every-day duties of a pharmacy. The worker in pharmacy finds constant use for his chemical and pharmaceutical knowledge from the cleaning of mortars and "graduates" to the most complex, difficult and delicate expert service, from the first day's experience of the beginner to the end of the apothecary's professional life.

Drug store work without any previous knowledge of drugs, of chemistry, of pharmaceutical nomenclature, or of the nature of pharmacy, and without any previous laboratory practice, is unintelligent and unsafe; such "practical experience" may be effective in all that relates to the purely mechanical mercantile duties of the drug store employé, but it is a slow, blind and wholly unsatisfactory method of learning the art of pharmacy.

Actual regular practice in a good pharmacy, after due preparation for it, is absolutely necessary to the completion of the training of an accomplished pharmacist. Shop experience as a part of the pharmacist's education does not derive its value from anything that the student or prospective pharmacist can learn far better in a good pharmaceutical school. The thoroughly practiced hand can be gained only by long practice; experience can come only by experience. Mercantile training, can, of course, never be imparted in the the college or school of pharmacy, nor can the college student be taught in school such things as bottling liquids, corking, wrapping, folding powders, spreading plasters, finishing and coating pills rapidly and to perfection, and the doing of many other similar things in a thoroughly workmanlike fashion. All of

these details can, however, be mastered by the beginner in the store far more rapidly, intelligently, safely and perfectly *after* such a preparation as a college course in pharmacy affords than before that course. A young man who has completed a good course at a school of pharmacy, including laboratory practice, can make many times as rapid progress in the practical every-day work of the store as the same young man would make without that preparation. Six months' practical experience *after a good college course* is worth more than four years' experience *before* it.

But the most important qualifications to be acquired by drug store practice are such as can never be tested, measured or demonstrated by any mere examinations, nor imparted by any other means than continuous experience of the right kind in a well conducted, well equipped and busy pharmacy. If all the qualifications which are to be derived from practical experience in drug stores could be ascertained by examinations, then the pharmacy laws need not demand any fixed period of actual regular service in a drug store. But no faculty or examining board can by any examination determine whether or not the candidate before them has had a sufficiently wide field of practice to develop and establish in him those qualities of reliability which no one can ever attain otherwise than by *long continued application of previously acquired special training to an active and varied daily experience*. The qualifications to be derived only from such practical experience are infinitely more important than the mere mercantile accomplishments which anybody can master without any previous scientific course.

The commercial druggist wants a clerk who can sell goods, draw custom and hold it, dress the show windows attractively, do his work quickly, get along with his routine duties without having to ask too many questions about prices and other mercantile details, etc. These qualifications are valuable, and can be acquired more easily by an intelligent and well educated person than by an unintelligent or poorly educated one.

But the qualifications contemplated by the pharmacy laws, when they require a certain number of years practical experience in drug stores, relate to the pharmaceutical work and are: matured judgement, a well grounded habit of circumspection, care, presence of mind, a conscientious feeling of personal responsibility, a healthy self-reliance, a full appreciation of the pharmacists relations and duties to the physician, the public and his profession, and a reliable tact in dealing with the numerous exigencies arising in the practice of pharmacy.

Pharmacists with extensive experience but with a very limited special education, or without any, can often give very valuable instruction to beginners who have had the best possible college course in pharmacy, because no observing man of intelligence can fail to learn from day to day many many important practical precautions and useful methods such as experience suggests. Young men who have a good knowledge of botany, materia medica, physics and chemistry, and who may know all the pharmacy, that they can gather from books, will, therefore, always find that they can learn a great deal more from experienced druggists or drug clerks, and they should never forget that the reliability and maturity of judgment based upon experience are entitled to the highest respect. A graduate in pharmacy who has had no drugstore experience previous to graduation will of course, prove to be a far more intelligent apprentice than the non-graduate and will in a few months develop into a more efficient and valuable clerk or assistant than the non-graduate would be likely to become in several years.

All beginners in the drug store should set to work systematically and diligently to learn all the details of the daily routine work with which they are concerned. Instead of devoting any portion of their time to idleness they should learn where to find and place things, familiarize themselves with the stock and with prices, practice making neat packages, and in every way seek to render their services as valuable as possible.

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PART I.

PHYSICS.

PART I.

PHYSICS.

CHAPTER I.

MATTER.

1. Physical Bodies are the things of external *Nature* which consist of matter (3).

Any portion of matter perceptible to our bodily senses is a *body*.

A body is an aggregation of any number of molecules (16 and 17).

We can also say that a body is any mass of matter *without reference to quantity*.

Ex.—Any piece of wood, stone or coal, any quantity of water, air or oil, a lump of sugar, a crystal of salt, any animal or plant, the paper upon which this book is printed, the printer's ink used in it, and the book itself as a material thing—all these are *bodies*.

[The term "body" is also often used in the same sense as the term "substance" (18); thus we find carbon described as a "fixed body" (83), while iodine is referred to as a "volatile body" (83). On the other hand, the term "mass" is commonly employed to designate an aggregation of any number of molecules (16) without regard to quantity. This use of the term *mass* is very convenient, but conflicts with the universal use of that term as defined in paragraph 7. In this book the term **body** will be used only to designate any body of matter without regard to the actual *quantity* (mass) of matter contained in it; and the term **mass** will be used in the sense fixed by its definition in par. 7.]

2. Mathematical Bodies represent form and extension, inclosing empty space, thus differing radically from physical bodies which contain or consist of matter (3).

We can think of and represent mathematical bodies, such as cubes, spheres, cones, cylinders, etc., without any reference to matter, because they have definite bounds although void of matter.

3.   **Matter** is that which occupies space or possesses extension.   By **matter** we also understand that which possesses *weight* (40) without regard to the *amount of space* which it occupies.

4.   Whatever occupies space is matter, and nothing can be matter which does not occupy space.

5.   No two bodies can occupy the same space at the same time, for every particle of matter occupies its own space, to the exclusion of every other particle of matter.

This property of matter is called **Impenetrability** (26).

Ex.—An egg can not be put in a tumbler previously filled with water without causing the water to overflow, because the egg necessarily displaces its own volume of water from the space occupied by it.

Air is matter. It, therefore, occupies space. When we speak of an "empty" bottle and an "empty" tumbler, and say that there is "nothing" in them, we ignore the fact that they contain air. Experimentally, you may prove this by inverting the tumbler and pressing it downward in water; if there were nothing in it, the water would fill it, but the water will *not* fill it because the air in the tumbler occupies the space and the water can not occupy it at the same time.

6.   Since by **Matter** we also understand *the weighable* without regard to its extension, it follows that whatever has weight (40) is matter, and that whatever has no weight can not be matter.

7.   **Mass**.—Any *amount of matter*, regardless of the space it occupies, is called **Mass**.

Since *matter* is that which is weighable, its *mass* is ordinarily measured by weight (40).

[But the *mass* of a particular body is a positive quantity, while its weight varies with its distance from the earth's surface (38).]

The Mass of a body, then, is the *actual quantity of matter* contained in that body, and mass has nothing to do with size or bulk.

8.   All material bodies have volume (9) and weight, as indicated in paragraphs 4 and 6.

9.   **Volume**.—The volume of a body is the space occupied by it.

All bodies have *extension* in all directions, and the measure of this extension is called *volume*.

Thus the length, breadth and thickness of a cubical crystal (130) indicate its extension and determine its volume.

Space devoid of matter is called *vacuum.*

10. The relation of mass to volume is called **Density**.

Density expresses the relative amount of matter contained in a given volume.

It is evident that bodies having the same volume may nevertheless have different masses, and that bodies having the same mass may have different volumes. Hence the necessity of the term " density " to express the relation of the mass (7) to the volume (9).

11. Of two bodies having the same volume but not the same mass, the one containing the greater amount of matter, or having the greater mass (7), has, therefore, the greater density (10).

In other words, the greater the quantity of matter contained in a given volume of a body, the greater will be the density of that body.

Ex.—Brass and bees-wax are bodies. Let us compare equal volumes of these bodies. A cubic inch of brass contains a greater amount of matter, or has a greater mass, than a cubic inch of wax; the density of brass is, therefore, greater than the density of wax.

Since matter is that which has weight (3) and mass is accordingly measurable by weight (7), a cubic inch of brass must weigh more than a cubic inch of wax if the brass is denser. Verify this by placing a piece of brass on one pan of the balance, and a piece of wax of the same size on the opposite pan; you will find that the pan loaded with the brass piece goes down, and the other up. If you now add as much wax to that already placed on the pan as may be necessary to counterbalance the brass, the bulk of the wax will be several times as great as that of the brass when their weight is equal.

12. Of two bodies having the same mass, each containing an equal amount of matter, but not of the same volume, the one having the smaller volume has, therefore, of necessity the greater density.

Ex.—A pound of lead and a pound of lard have the same mass, because they have the same weight (40), but the pound of lead occupies much less space (or has a less volume) than the pound of lard; therefore, the density of lead is greater than the density of lard.

13. When two or more bodies are of like density, their relative masses correspond to their relative volumes.

Ex.—Castor Oil and Copaiba have the same density; therefore, it follows that one pound of castor oil has the same volume as one pound of copaiba; it also follows, that if one bottleful of castor oil weighs three times as much as another bottleful of copaiba, the bottle containing the castor oil must have three times the capacity of the one containing the copaiba, and the volume of the oil must be three times as great as the volume of the copaiba; and sixteen pints of copaiba must weigh sixteen times as much as one pint of castor oil.

14. Having now learnt what is meant by each of the terms body (1), matter (3), mass (7), volume (9), and density (10), let us next consider some of the *general properties of matter* (or the "universal properties of matter").

We have already seen (3) that all matter occupies space and has weight. But volume and weight are not properties of matter, for we can think of space without reference to matter, and weight is an effect produced upon matter by a cause external to and distinct from it (40).

One of the "general properties of matter" has been noted, however, namely its *impenetrability* (5).

As we will presently find (17) there are very numerous *forms* or different *kinds of matter*, each particular kind possessing its own *specific properties;* but all of these different kinds of matter possess certain properties in common, and the properties which are common to all matter are called *the general properties of matter.* Among them are: Divisibility (15), Porosity (25), Impenetrability (26), Indestructibility (27), Compressibility (29), Expansibility (29), Elasticity (30), and Inertia (31).

15. **Divisibility.**—We know from experience that all larger bodies can be divided into smaller bodies. Large pieces of stone upon the public road are ground up into fine dust. It is impracticable to determine by the aid of our physical senses, the extent of this divisibility of bodies, but it is evident from the fact that matter occupies space, and is impenetrable, that, however small the individual particles may be made, mere mechanical division can effect no other change but that of reducing the size of each portion.

In order, however, to account for the changes and conditions

of matter which have been observed, it is assumed that all matter consists of particles of definite size called molecules (16).

The possible physical divisibility of matter, therefore, extends to its molecule, but no further.

16. Molecules, then, are the smallest particles of any given kind of matter that can subsist alone, or the smallest particles into which any kind of matter can be divided without losing its identity or without being changed into some new kind or kinds of matter.

17. Kinds of Matter.—There are numerous kinds of matter. Indeed, the distinct kinds of matter already known are countless, and new kinds are daily discovered. It follows from what was stated in paragraph 16 that there are as many kinds of matter as there are different kinds of molecules, and *vice versa*.

18. Substance.—The word substance will be used to designate a particular *kind of matter*.

19. From what has been said (16) you are to infer that molecules are *not* absolutely indivisible; for, while it is true that whenever the molecule of any substance is divided, that substance ceases to exist *as to its kind,* being converted into some other substance or substances, all molecules may be divided into still smaller particles called **atoms** (20), which are, with rare exceptions, incapable of subsisting separately or in a free state, but which unite with each other to form molecules and are capable of being transferred from one molecule to another.

20. Atoms are the smallest particles of matter that can take part in the formation of molecules. They are indivisible, physically and chemically (22).

The reasons for supposing that matter is not divisible without limit, but that all matter consists of indivisible particles (called atoms) will be stated further on in (577, 580).

21. Atoms unite with other atoms either of the same kind or of different kinds, forming molecules.

22. When molecules are divided, disrupted or decomposed into their constituent atoms, these atoms rearrange themselves immediately to form new molecules. The division of the molecule is not mere mechanical division, or a physical division, but it is *chemical decomposition.*

23. All changes which take place within the molecule, or which involve the division of molecules, belong to the domain of **Chemistry.**

24. The subject of the divisibility of matter is so important as to justify a recapitulation here.

With regard to its division, matter may be considered in three distinct conditions; namely, its Molar condition, its Molecular condition, and its Atomic condition.

1. Molar matter, or the material bodies ("masses of matter") perceptible to our senses. Bodies or masses of matter (1) are made up of molecules held together by molecular attraction.

2. Molecular matter, or molecules (16) composed of atoms held together by atomic attraction. The molecule is the smallest particle of any kind of matter that can subsist, as it can not be divided without being transformed into some other kind or kinds of matter.

3. Atomic matter, or atoms (20) of matter, or particles of matter which can not be divided by any means. Atoms unite with each other chemically to form molecules, and can pass from one molecule to another, but are incapable of separate subsistence.

25. Porosity.—Pores are the extremely minute spaces between the molecules of bodies. All bodies are porous. This property is accounted for by the hypothesis that the molecules are not in actual contact.

Distinction should be made between the invisible *physical pores*, which are above referred to, and the *sensible pores*, which are the actual cavities observed in porous substances like pumice stone, filter paper, unglazed earthenware, etc.

26. We may now refer once more to the **impenetrability** of matter. Since the molecules of a body are not in actual contact with each other, two different substances may be intimately *mixed* with each other, the molecules of one occupying a portion of the space between the molecules of the other, as in a solution of sugar in water, but the *molecules can not penetrate each other* (5).

27. Indestructibility.—Matter can not be annihilated. It

can be changed as to its kind but not as to its amount. The amount of matter in the universe can neither be added to nor diminished. It is uncreatable as well as indestructible (490).

28. Contraction and Expansion of Volume.—By reason of its *porosity* (25) matter may be made to occupy more or less space without change of mass. Not being in actual contact with each other, the molecules may be brought nearer to each other by compression of the body or by a reduction of its temperature ; or they may be separated further from each other by the withdrawal of pressure or by the aid of heat.

29. By the **Compressibility** of matter we understand that masses of matter can be compressed or forced to occupy less space without diminution of mass.

By **Expansibility** is meant the opposite of compressibility. Bodies can be made to occupy more space without any increase of their mass.

30. Elasticity is the property by virtue of which a body which has been compressed or expanded by some force external to itself resumes its original volume.

31. Inertia is a term used to express the recognized inability of matter to move without the impulse of some force external to itself and its inability to stop of its own accord when once put in motion.

Matter at rest must remain at rest until put in motion by some force, and matter in motion must continue in motion until its motion is arrested by some force.

32. Among the *specific* (or characteristic) *properties* of matter are: **Hardness,** by which some substances more or less strongly resist superficial impression or scratching; **Tenacity,** by which some kinds of matter resist more strongly than others an effort to pull their bodies apart; **Brittleness,** or the property of being easily crushed; **Malleability,** or the property by virtue of which some metals may be rolled or hammered into plates or sheets, and **Ductility,** which renders it possible to draw certain metals into wire.

The "specific properties" enumerated and defined in the

preceding lines depend chiefly upon the various states and degrees of cohesion and adhesion.

Other *characteristic* or *specific* properties of different kinds of matter are such as peculiar form, color, odor, taste, solubilities, melting point, boiling point, molecular weight, relative stability of their molecules, etc.

CHAPTER II.

FORCES AND PHENOMENA.

33. Phenomena.—The changes occurring in the form, condition, and properties of matter are called *phenomena*. They are caused by *forces* (34 to 36) operating in accordance with fixed *laws of nature*.

34. Force is whatever produces, changes, or arrests motion (59). It manifests itself under various forms. Like matter it is uncreatable and indestructible. It can neither be added to nor diminished.

35. Attraction and **Repulsion.**—All particles of matter possess a tendency to attract and to repel other particles of matter. All *motion* (59) is the result of these pushes or pulls, which are caused by the *attractive* and *repellant* forces. *Attraction* and *repulsion* co-exist, and the resultant motions and conditions of matter vary as the one or the other predominates.

36. All attraction and repulsion between different portions of matter are *mutual*. Thus if the body A attracts the body B to itself, A is also attracted by B, and if one particle of matter repels another the repulsion is reciprocated.

37. Attraction is called *molar attraction*, or "mass attraction" when it operates between bodies of matter, or between masses of molecules.

The attraction between molecules is called *molecular attraction*.

The attraction between atoms is called *atomic attraction*, chemical attraction, or *chemical affinity*.

GRAVITATION.

38. Molar attraction affects all bodies at all distances. Thus all bodies in the universe are mutually attracted to and by each other. The relative measure of this attractive force is in direct ratio to the masses of the bodies, and at the same time in inverse proportion to the squares of their distances from each other.

The greater the mass of a body, the greater will be the result of its attracting force exerted upon other bodies, and the greater also the force with which it is itself attracted toward larger bodies. The further apart two bodies are from each other, the weaker the attraction between them.

This universal attraction which operates between all bodies is called **Gravitation**.

The laws which govern this mass attraction and its relative force, direction, and results, are called the *laws of gravitation*.

39. The planets and all other bodies in the universe are held in their positions by gravitation.

Gravitation is operative between the earth and any one of the heavenly bodies, between the heavenly bodies respectively, between all bodies upon the earth's surface, or between any two bodies.

40. Weight.—The mass of the terrestrial globe being greater than that of any other body in its atmosphere we ordinarily take notice only of that attraction which the earth exerts upon all bodies upon or near its surface.

The ruling power by which the earth attracts toward its center other bodies of lesser mass is called **weight.**

Thus it is the pressure which a terrestrial body exerts upon a horizontal plane which prevents it from falling.

It may also be said to be the force required to neutralize the earth's attraction upon a body on or near its surface.

41. Gravity.—A body whose gravitation is exactly equal in all directions, remains in the same position though it may be suspended in space. Such a body, in relation to other bodies, has *gravity* but not weight.

Sometimes "gravity" is defined as "the attraction between the earth and bodies upon or near its surface;" thus, that which we have called

"weight" in par. 40; and when gravity is thus defined, the term weight is defined as "the measure of gravity."

42.   Weight is considered in two different ways—1. As *absolute weight* (43), which is weight without reference to volume; and 2. *Specific weight* (47), which is the ratio of weight to volume.

43.   **Absolute weight** is expressed in units of fixed value which are chosen as standards of comparison.   The British standard of weight is the *avoirdupois pound*, which is made of platinum and copies of which are used for weighing things; the standard of weight used in science, and in the greater part of the civilized world for all other purposes, is the *Gram*, which represents the weight of one Cubic-centimeter of water.

44.   *True weight* is the weight of a body in a vacuum (9).

45.   *Apparent weight* is the weight of a body in air or in any other fluid (80).   [See also 261-266.]

46.   When we say that one piece of iron is heavier than another piece of iron, that a pound is lighter than a kilogram, or that a cubic inch of water weighs more than a cubic centimeter of the same liquid, we are comparing their **absolute weights**, and the differences are accounted for by the fact that their volumes differ.   In other words absolute weight may be determined and expressed without reference to volume.

47.   **Specific Weight** is the relation of the weight of a body to its volume.

It is nearly synonymous with *density* (10), for the specific weight of a body must necessarily be in direct ratio to the mass as compared with the volume, and we know that the greater the mass of a terrestrial body the greater will be the gravitating force by which it is drawn towards the center of the earth (40).

Specific weight may also be said to be the relative gravitating force of one substance as compared with that of a like volume of some other substance.

48.   When we speak of iron as being heavier than chalk, or say that ether is lighter than chloroform, it is always understood that the comparison refers to equal volumes, and the weights referred to in this connection are, therefore, the *specific* weights proper to these substances respectively.

When equal volumes of any two or more substances are weighed, we generally find that their weights differ. That is because their densities differ. And the differences in weight caused by differences in density are indicated by the specific weights.

49. In order to express the specific weights of substances some one substance must be chosen as the standard of comparison. Thus the standard of comparison adopted for all solids and liquids is water, while the standard of comparison now used in expressing the specific weight of gases is hydrogen.

[Formerly the standard unit for gases was the specific weight of air; but, for reasons which you will better appreciate as you learn chemistry, it is far more convenient as well as scientific to adopt the hydrogen unit.]

50. Thus the specific weight of water is called 1, and as the specific weights of all solids and liquids are expressed in water units it follows that any substance which is only half as heavy as water has the sp. w. 0.500 and any substance twice as heavy as water has the sp. w. 2. As a cubic inch of silver is 10½ times as heavy as a cubic inch of water, the sp. w. of silver is 10.500 (water=1); if a cubic foot of glass weighs three times as much as a cubic foot of water, the sp. w. of that glass is 3.000; since the weight of any given volume of mercury is 13.596 times the weight of the same volume of water, the sp. w. of mercury is 13.596 (water=1). Ice weighs only 0.930 times as much as the same volume of water; therefore, the sp. w. of ice is 0.930 (water=1.)

51. In stating the specific weights of gases, we call the sp. w. of hydrogen 1, and the specific weights of all other gases are expressed in hydrogen units. Thus Oxygen has the sp. w. 16 (H=1), for a liter of oxygen weighs sixteen times as much as a liter of hydrogen; but chlorine is heavier than oxygen, any given volume of chlorine being 35.45 times as heavy as an equal volume of hydrogen, the sp. w. of chlorine being, therefore, 35.450 (H=1).

52. Compared with each other the specific weights of the substances used as standards of comparison for other substances are *about* as follows at the temperature of 15° C. (59° F.) Water 1 (water=1), or 11,400 (H.=1), or 815 (Air=1). Hydrogen 1

(H.=1), or 0.0691 (Air=1), or 0.000085 (water=1). Air 1(Air=1),
or 14.44 (H.=1), or 0.00122 (water=1).
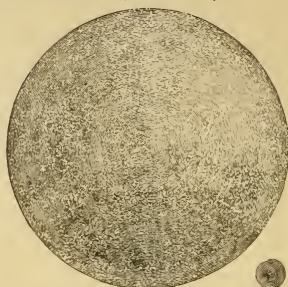
Fig. 11   Fig. 12

Fig. 1 Represents the volume of one grain of air. Fig. 2. the volume of one grain of water.

Thus water is about 11,400 times as heavy as hydrogen, and 815 times as
heavy as air (see figures 11 and 12); hydrogen is 0.0691 times as heavy as air, and
0.000085 times as heavy as water; air is 14.44 times as heavy as hydrogen,
and 0.00122 times as heavy as water.

53. The expression "specific gravity" is generally used
instead of the more correct expression *specific weight.* As com-
monly employed both expressions mean precisely the same
thing.

MOLECULAR ATTRACTION.

54. **Molecular attraction** is of two kinds—*Cohesion* and
Adhesion.

55. **Cohesion** is that molecular attraction which operates
between the like molecules of a chemically homogeneous body.

56. **Adhesion** is the molecular attraction which holds
together the unlike molecules of mixtures, or which operates
between the molecules of two or more different substances.

57. **Atomic Attraction** governs the relative stability of
different kinds of matter. It causes the change of particular
kinds of matter into other kinds when the conditions are favora-
ble. It renders possible the assimilation of food by plants and

animals. Decay and decomposition, as well as the formation of new substances out of the debris, are the results of atomic attraction.

It will be considered further on more fully under the head of *chemistry*.

58. Energy, which is the power to do work, or to overcome resistance, is the product of *force* (34). A force does work when it produces or arrests motion (59).

59. Motion is a change of place. We are to distinguish between *molar*, *molecular* and *atomic* motion.

60. Molar Motion, or "mass motion," and molar force, pertain to bodies of matter.

Dynamics (197) treats of the states and motions of matter in its molar condition, and of the relations and results of molar attraction and repulsion. Dynamics is a more comprehensive term than the expression "mechanical science" which treats of the application of dynamics to the accomplishment of useful work, the construction of machines to that end, etc.

61. Molecular Motion, or the molecules within the body or "mass," is distinct from both molar and atomic motion. The mass may be at rest while its molecules are constantly in motion. The motion of the molecule is distinct from the motion of the atoms of which it consists.

Molecular motion never ceases.

62. But while the whole body may move independently of the motions of its molecules, the several modes of molecular motion involve the whole mass, all of its molecules being affected.

Molecular motion is vibratory—not progressive.

63. Among the modes of molecular motion are **Sound, Heat** (305), **Light** (412), and **Electricity** (430).

64. Atomic Motion, or the motion of the atoms (20), within each molecule (16), is doubtless as never-ceasing as molecular motion (61), although its existence has not been demonstrated.

In chemical reaction (493), the atoms must be extremely active.

But we must defer the consideration of atomic attraction

and repulsion, and the resultant atomic activity until we reach the subject of Chemistry.

65. Recapitulation.—Having now learned that the various modes of molecular motion, or manifestations of energy, are what we call sound, heat, light and electricity, we may close this chapter by the statement that these several different forms of motion are interconvertible.

66. Correlation of Energy.—Energy of any kind can be changed into energy of any other kind. Thus, the different forces are only different forms of one universal Energy and mutually interchangeable.

67. Conservation of Energy.—Whenever any form of energy disappears, its exact equivalent in another form takes its place, so that the total sum of energy in the Universe remains unchanged.

CHAPTER III.

PHENOMENA DEPENDENT UPON COHESION.

68. The three states of aggregation of matter are the *solid*, the *liquid*, and the *gaseous* state.

69. Solids are bodies in which the molecules are held together so firmly by *cohesion* (55) that they retain their form without support, under ordinary conditions (of pressure and temperature), and can be changed as to their form only by external violence, or by the influence of heat (375), or by solution (183).

Ex.—All metals, except mercury, are solids. Rocks, trees, ice, butter, paper, cobweb, pieces, particles of powder, dust—all these are solid bodies.

70. According to their consistence the solids are hard, soft, tough, brittle, elastic, rigid, flexible, malleable, ductile, etc. Several of these terms will be understood by reference to par. 32, while others explain themselves or may be found in any dictionary.

FORMS OF SOLID BODIES.

71. The greater number of solid bodies do not exhibit any definite or regular form. Yet many organic substances (454), formed in plants or animals, show a tendency toward the formation of more or less globular masses, and many inorganic substances together with a large number of products of the chemist's laboratory, have well defined angular geometric forms, called *crystals* (84).
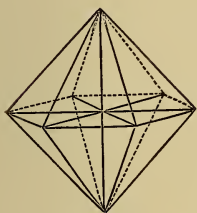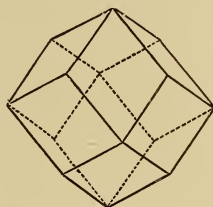
Figure 13   Figure 14   Figure 15

[See *crystalloids* and *colloids*, par. 179.]

72. Substances occurring in crystals or crystalline masses are called *crystallic*, or *crystalline* (89) substances; all others are said to be *amorphous* (96), or formless.

73. Solids which are not altered by exposure are said to be *permanent in the air*.

Those that absorb moisture from the air are *hygroscopic*, and if they take up so much moisture as to become quite wet, they are *deliquescent*, dissolving in the water they attract.

Crystallic and crystalline substances, when they give up their *water of crystallization* (121) on exposure to the air, thereby losing their crystalline form, are called *efflorescent* (123).

Ex.—Gold, corrosive sublimate, cream of tartar, are "permanent in the air."

Squill and gentian are "hygroscopic."

Chloride of iron, potassium carbonate and zinc chloride are "deliquescent."

Copperas, washing soda and Glauber's salt "effloresce."

74. Liquids have apparently no form of their own.

In very small particles of liquids the cohesion overcomes gravity (provided adhesion between the liquid and other sub- stances do not interfere), so that the molecules, attracted toward the center of the mass, form spheres or spheroids, as may be seen in drops of dew, globules of mercury or drops of water rolling upon a surface dusted with lycopodium. Drops of olive oil will float about in a mixture of six cubic centimeters of alco- hol and four cubic centimeters of water, the drops of oil exhib- iting a perfectly spherical form.

But when the body of liquid is larger, the force of cohesion is overcome by the force of gravity which tends to bring the molecules to the same level, and the liquid then assumes the shape of the vessel in which it is contained. When the support around the body of liquid is taken away, the liquid, impelled by gravitation, spreads outward and downward over the solids in its way.

Water is a most familiar and perfect example of liquids. Alcohol, ether, chloroform, glycerin, fixed oils, syrups, tinct- ures, sulphuric acid and mercury are other examples of liquids.

75. Liquids are not easily compressed. To compress their volume requires very great force; the compression is but slight, and on removal of the pressure they immediately resume their original volume, being perfectly *elastic*.

The enormous pressure necessary to compress water in any appreciable degree warrants the conclusion that liquids are *prac- tically incompressible*.

76. Liquids may be *viscid*, like tar, honey, or thick mucilage, or they may be *mobile*, like chloroform; they may be *heavy*, like sulphuric acid, or *light*, like ether.

Honey, tolu, storax, oleate of mercury and many other substances are frequently in such a condition that it is not easily determined whether they ought to be called solids or liquids.

Very thick, sluggish liquids and solids approaching a liquid condition—in other words, substances partaking of the consist- ence of both solids and liquids—are called *semi-solids*, or *semi- fluids*.

They are simply substances whose melting points or congealing points (376) are the common temperatures of the air or of our warehouses, shops and work-rooms.

77. **Gases** are aeriform bodies, or bodies like air, which, being neither solids nor liquids, do not retain a definite shape, or outline of their mass, when put in an open vessel, as the cohesion between their molecules is nullified (81).

Gases, instead of being governed by cohesion (55), resist compression (29) of volume by a certain degree of force called *tension* (279). Their molecules, therefore, seem to be governed by repulsion instead of by attraction (35). Accordingly, they diffuse themselves in every direction through space.

78. Colorless gases are invisible, and this explains why their existence is unknown or unreal to the ignorant. Air, illuminating gas, "natural gas" (which is mainly marsh gas, or methane), gasolin vapor, oxygen, hydrogen, ether vapor, alcohol vapor, are invisible.

But there are also a few colored gases, as chlorine, which is greenish; iodine vapor, which is violet; nitrogen tetroxide, which is red, etc.

79. The term **vapor** is used to designate gases which exist as such only at temperatures above the ordinary, and which, under ordinary conditions of temperature and pressure, assume the liquid or solid state.

80. In physics (485) the word **fluid** is used to designate any or all bodies whose molecules easily change their relative positions within the mass—in other words, to designate liquids (74), gases (77) and vapors (79).

81. The three different "states of aggregation" depend upon the relative force of molecular attraction and repulsion. When the attractive force (cohesion) exceeds the repellant force the body is solid; when molecular attraction and repulsion are equally balanced the body is a liquid; and when the repellant force predominates, the gaseous state is the result.

It is, therefore, said that "cohesion is absent in gases." It is, however, not absent, but simply rendered inoperative.

82. Many substances are capable of assuming either of the three states of aggregation. Others again only one; and others two.

Carbon is known only in the solid state; lead is known as a solid, and in its fused condition as a liquid, but not as a vapor; water is solid, as ice, liquid in its ordinary condition, or gaseous as water vapor.

83. Fixed substances are such substances as can not be made to assume the gaseous state.

Volatile substances are liquids and solids which are very easily converted into vapor (79).

CHAPTER IV.

CRYSTALLINE BODIES.

84. Crystals are regular geometric solids with smooth *faces* meeting in straight *edges* and forming perfect *angles* or corners bounded by three or more of the faces (Fig. 16.)

Crystals are formed by a definite arrangement of the molecules of matter in accordance with natural laws.
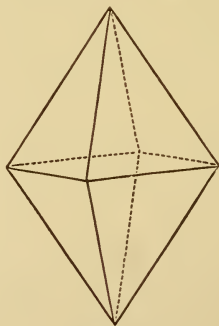
Figure 16

85. That the crystalline form depends, at least in part, upon the attraction called cohesion (55) is self-evident; but it is not

known why or how the molecules of any particular kind of matter thus arrange themselves into given forms.

86. Numerous examples of crystallization are found in the mineral kingdom. Mineral crystals formed in the interior of the earth were probably produced from matter in a state of fusion at extremely high temperatures.

The remarkably pure *calcspar* (calcium carbonate) from Iceland, the pure silicic acid known as *rock crystal*, and the highly prized *diamond* (carbon) are beautiful examples of crystals.

The Iceland spar is a prism, rock crystal is a prism with pyramidal ends, and the diamond is a double pyramid (112).

Galena (lead sulphide) furnishes an example of the cubical form (130).

But fine specimens of crystals may also be produced in the laboratory, and even commercial chemicals frequently exhibit well formed crystals. You might find some good crystals of copper sulphate, ferrous sulphate, alum, zinc sulphate, lead acetate, quinine sulphate, and many other substances.

87. There are innumerable forms of crystals, but as a rule each particular kind of matter crystallizes in but one form; rarely the same substance crystallizes in two or even three forms.

88. As each crystallizable substance generally forms but one kind of crystals, the crystalline form is one of the means of identification of the respective species of matter.

Thus, knowing that potassium iodide crystallizes in cubes and in no other form, we know also, that any substance exhibiting some other crystalline form can not be potassium iodide.

89. *Crystallizable substances* are those capable of assuming a crystalline form.

Crystallic substances are those occurring in comparatively well defined, free or detached crystals; like copper sulphate, alum, potassium bicarbonate, sodium phosphate, lead acetate, quinine sulphate, salicin.

Crystalline substances are those having an evident crystalline structure, but not consisting of well developed and detached crystals; as ferric chloride, potassium acetate, black antimony sulphide, camphor, bismuth subnitrate.

90. Dimorphism.—Substances capable of crystallizing in two different forms are said to be *dimorphous*.

Calcium carbonate occurs, as calcspar, in rhombohedrons of the hexagonal system, and, as arragonite in prisms of the rhombic system.

91. Polymorphism.—Substances occurring in more than one distinct crystalline form are sometimes referred to as *polymorphous bodies*.

Trimorphous substances are those occurring in three different crystalline forms, of which titanic oxide is an example.

92. Changes in crystalline form often result from different proportions of *water of crystallization* (121).

93. Isomorphous substances are different substances crystallizing in the same form.

Entire groups of chemically related compounds may have similar crystalline forms. Bromide and iodide of potassium both crystallize in cubes.

But the term *isomorphism* is understood to involve more than similarity or sameness of crystalline form (94).

94. In 1819 Mitscherlich made the important discovery that compounds of analogous chemical structure may not only have the same crystalline form, but that the corresponding elements in their constitution may be interchangeable in any proportion. The double salts called *alums* are examples of perfect isomorphism. They are formed from the sulphates of either potassium, sodium or ammonium, with the sulphates of either aluminum, iron or chromium, all giving crystals of the same form (Octohedrons), and the respective sulphates of potassium, sodium and ammonium are mutually interchangeable, in whole or in part, in these several kinds of alums, as are also the aluminic, ferric and chromic sulphates.

But even bodies not completely analogous as described, may have the same crystalline form.

Mitscherlich concluded that all molecules containing the same number of atoms arranged in the same manner have the same crystalline form, without regard to the *kinds* of atoms entering into the molecules. This rule has, however, been found to be subject to many exceptions. Kopp regards as isomorphous only compounds the crystals of which can grow in each other's solutions. A crystal of common alum will increase in size when placed in a solution of iron alum; hence these alums are isomorphous.

95. Heteromorphous substances are any two or more substances which crystallize in different forms.

96. Amorphous substances.—Literally translated the word *amorphous* means *formless*. In chemical physics and in the description of pharmaceutical chemicals and other substances

the term is used to designate *substances without any indications of crystalline structure.*

97. It is not to be supposed, however, that the forms assumed by all amorphous solids are devoid of regularity when their molecules are permitted to range themselves in comparative freedom. On the contrary where the straight lines and the perfect angles and faces of the crystal are absent, we may expect indications of a tendency to a spherical or bead-like form.

Substances which take part in the physiological processes of animal or vegetable life, belonging to what has been called "organized matter," have not the property of forming crystals, although crystallized substances are frequently found deposited in the tissues of both plants and animals.

Amorphism is the rule and the crystalline form exceptional among natural products derived from the animal and vegetable kingdoms.

Cellulose, starch, gum, albumen, and many other proximate principles contained in plants, are amorphous.

Examples of inorganic amorphous solids are found in clay, ferrous sulphide, zinc oxide, ferric hydrate, basic ferric sulphate, aluminum hydrate, precipitated calcium phosphate, and yellow oxide of mercury, as prepared in accordance with the pharmocopœias.

98. Many substances occurring in amorphous conditions may, however, also exist in crystalline forms. Moreover, numerous substances, which to the unaided eye appear without the slighest evidence of crystalline form, and which occur as impalpable powders, and are, therefore, described as amorphous, consist in reality of minute crystals plainly visible under the microscope. The latter may be called *micro-crystalline.*

99. When liquids are divided into minute particles, each particle assumes a spherical form by virtue of the force of cohesion, and retains that form until its cohesion is overcome by some other force, as by adhesion. A drop of oil retains its spherical form when floating in a liquid of equal density in which the oil is insoluble; but it loses its form when resting upon the surface of some solid.

100. **Crystals grow** from without by the deposition of additional solid matter upon their surfaces. Each larger crystal is then an aggregation of innumerable smaller crystals of the same form. Each smallest crystal in such an aggregation may be regarded as an individual. Whether or not the crystalline form represents the form of the molecule itself is a secret of nature which may perhaps never be discovered.

101. Being solids, all crystals must of course extend in at least three directions. Sometimes their extension is in four directions.

CHAPTER V.

HOW CRYSTALS ARE FORMED.

102. Axes.—The directions of extension of crystals are called their *axes*. These are imaginary straight lines intersecting each other at one point in the center of the crystal, and terminating either in the centers of opposite faces, or in the apices of opposite solid angles. (See Plate A.)

103. Planes or Faces.—The smooth, plane surfaces of crystals are called *faces*. They are bounded by three or more straight sides, each side matching that of the contiguous face. The smooth surfaces exposed by *cleavage* are the faces of crystals.

According to the number of their faces crystals are called " tetrahedrons " when they have four faces, "hexahedrons" when they have six, " octohedrons " when they have eight, "dodekahedrons " when they have twelve faces, etc.

104. Edges are formed by any two contiguous faces. These edges, or *angles of incidence*, or the respective inclination of the faces to each other, are characteristic of the primary forms of each particular species, and thus furnish the means of determining which system crystals belong to, by measuring their *facial angles*.

This is done with the aid of an instrument called a *goniometer*.

105. Angles.—The angles of crystals are the *solid angles* formed by three or more contiguous faces meeting in a point.

Thus each corner of a cube is a three-faced angle; the apex of a hexagonal pyramid is a six-faced angle; and octohedrons have six four-faced angles

According to the number of their angles crystals are called tetragons, hexagons, octagons, etc.

106. Fundamental Forms of crystals are the simple dominant forms of the several systems (129).

107. Simple Forms.—Crystals bounded in all directions by similar faces are called *simple forms*, as shown in galena and in the diamond (Figs. 17 and 18).

108. Complex Forms are those having dissimilar faces, as shown in the rock-crystal and the calcspar. Complex forms are always combinations of two or more simple forms.

The largest faces in a complex crystal are called the *dominant faces* because they determine the dominant form of the combination. The smaller faces are called *subordinate* or *secondary faces*.
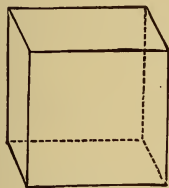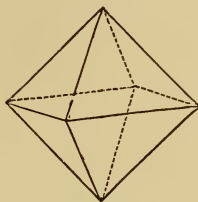
Figure 17   Figure 18

109. Crystal forms in which all the possible faces are present, making the crystal complete, are called *holohedral forms.*

When only one half of the normal number of faces are present, the crystal being thus only one-half developed, the form is called *hemihedral.*

Forms with only one-fourth of the normal number of faces developed are also known.

110. Cleavage.—By carefully-directed gentle blows, or with the edge or point of a knife, an irregular mass of a crystalline body, or a single crystal, can be split in certain directions so that plane, smooth faces are produced. The body can then be split into layers parallel with the surfaces thus exposed. This is called *cleavage.* The crystal or mass frequently splits more readily in one direction than in others.

A perfect crystal may thus be obtained by the dissection of an apparently shapeless mass in the directions indicated by the cleavage.

The simple form from which a secondary form is derived, may be discovered with the aid of cleavage dissection. Thus a hexagonal prism of Iceland spar may be reduced by cleavage to an obtuse rhombohedron.

111. The axis of symmetry is an imaginary straight line drawn through the center of the crystal, and around which its parts are symmetrically arranged.

112. Three general forms of crystals are to be distinguished: the *cubical form*, the *prism* or long columnar form, and the *pyramid* or pointed form.

These forms are modified and combined into numerous varieties. Thus there are prisms with pyramidal ends, double pyramids, or two pyramids placed base to base, etc.

The cube is seen in potassium iodide; the prism in Rochelle salt; the pyramid in potassium sulphate.

113. Prisms are called *open forms* because their lateral faces are parallel so that the length of the crystal is indeterminate.

Pyramids and double pyramids are called *closed forms* because they terminate at the apices.

114. Crystalline structure in soluble bodies when not apparent on the surface, or when so confused that the form can not be recognized, may often be discovered by slow solution of the broken crystals on the exterior. This may be effected by means of a nearly saturated solution of the same substance, such a weak solvent being sufficient to break down the fragments of already broken crystals but not sufficient to overcome the cohesion of whole faces and angles.

115. Crystalline form as an evidence of definite chemical composition.—Only bodies having a definite chemical structure are capable of assuming the crystalline form.

A substance known to be crystallizable is less liable to suspicion as to its purity when in crystals than in any other condition. But a crystallic form is far from sufficient evidence of purity, for not only do isomorphous substances crystallize together, but the crystals of one salt, however distinct, may still contain small amounts of heteromorphous salts as impurities.

116. Crystallization is resorted to as a means of separating salts from each other, and thus for purposes of **purification,** because substances which do not crystallize in the same form do not crystallize together in the same crystals.

Perfect purification or complete separation by crystallization is, however, difficult unless the several substances to be thus separated from each other differ in solubility, when the less soluble substance will crystallize before the more soluble one.

117. The presence of one substance in the solution of another may have the effect of causing the latter to crystallize in the form peculiar to the other.

Thus, if a solution contain the sulphates of copper and iron (ferrous), and there is more than one molecule of ferrous sulphate present for every eight molecules of the copper sulphate, the copper salt will crystallize in monoclinic prisms, which is the form of the crystals of ferrous sulphate, instead of in the triclinic form, which is the normal form of crystals of copper sulphate (Lecoq de Boisbandran).

118. Crystallization.—Crystals are most readily and commonly formed when substances pass from a liquid or a gaseous condition into the solid state.

Crystallization may, however, also take place in a solid body without previous fusion, solution or vaporization, as for instance in arsenous oxide, which slowly changes from the colorless, glassy, transparent amorphous to an opaque, white, crystalline condition. A similar change from a glassy structure to a more or less distinctly crystalline character is also to be seen in so-called *barley sugar*, or melted candy, as when clear lemon drops change to an opaque condition.

119. How crystallization is effected.—Solution, fusion and sublimation are the usual means of inducing crystallization. Large, well-defined crystals are frequently obtained when crystallizable salts slowly deposit from solutions of suitable degree of concentration. Highly developed crystalline forms are also sometimes obtained by fusion and by sublimation. Minute crystals are often formed when new compounds are produced by precipitation.

CHAPTER VI.

WATER OF CRYSTALLIZATION.

120. Anhydrous crystals are those which contain no water of crystallization (121).

They may, however, contain small amounts of *interstitial water* imprisoned between the individual crystals. In that case they often burst asunder with a slight explosion when heated. This is called *decrepitation*, and sodium chloride affords a familiar illustration of it.

Heat a crystal of common salt and see how it bursts with a smattering noise.

121. Hydrous crystals contain water essential to the crystalline form.

The water entering into the composition of hydrous crystals is called **water of crystallization**.

122. Some salts combine with various proportions of water of crystallization, according to the temperature at which the crystals are formed, assuming different forms according to the amount of water they take up.

Manganous sulphate crystallized at or below 6°. C. (42°.8 F.) contains seven molecules of water; crystallized at from 7°. to 20°. C. (44°.6 to 68°. F.) it contains five molecules, and when crystallized at 20°. to 30°. C. (68°. to 86°. F.) it takes up only four molecules of water of crystallization.

Sodium phosphate when crystallized from a solution saturated at about 30°. C. (86°. F.) contains twelve molecules of water; but a solution saturated at 40°. C. (104°. F.), or over, will, on cooling, deposit crystals with only seven molecules of water of crystallization.

Sodium carbonate as found in commerce contains ten molecules of water; at 30°. C. (86°. F.) it may be obtained with nine molecules, at 25°. C. (77°. F.) with seven, and at 12°. C. (53.°6 F.) with five molecules of water.

Copper sulphate ordinarily crystallizes with five molecules of water. If, however, an effloresced crystal of nickel sulphate be added to a supersaturated solution of copper sulphate, crystals of the latter salt are deposited which contain six molecules of water; but if a crystal of ferrous sulphate be instead added, the crystals obtained contain seven molecules of water.

Zinc sulphate ordinarily contains seven molecules of water of crystallization; but when crystallized from a warm (over 30°. C.) concentrated solution the crystals formed contain only five molecules of water.

123. Some hydrous salts readily part with their water of crystallization even at ordinary temperatures, losing their crystalline form, usually falling into powder, and are then said to *effloresce* (73).

Others lose their water of crystallization without losing their crystalline form and then become opaque, as acetate of copper.

At temperatures above summer heat many hydrous salts effloresce, and when heated up to about 100° C. (212° F.), most of them give up the greater part of their water of crystallization. In many cases it requires very high heat to expel all of the crystal water, as for instance is the case with the sulphates of zinc and iron.

124. Not all of the water of crystallization is held by the substance with the same force.

Magnesium sulphate (Epsom salt) gives up one of its seven molecules of water at 30°. to 52°. C. (86°. to 126°. F.); four additional molecules of water are expelled by water-bath heat; and by stronger heat the salt may be rendered anhydrous.

Potassa-alum contains 45.57 per cent. of water of crystallization. When heated to 40°. C. (104°. F.) it loses about 2 7 per cent. of that water; at 47° C. (116.°6 F.) it loses 9.6 per cent.; at 60°. C. (140°. F.) it loses most of its water, but the crystals still retain to a great extent their form, and the product, which is not yet porous, yields a clear solution with water; at 80°. C. (176°. F.) the alum effloresces completely, but still holds a considerable amount of water; long continued heating at 100°. C. (212°. F.) expels all of the water and leaves a product which is entirely water-soluble; when heated at once at over 92°. C. (197°. F.) the alum undergoes aqueous fusion (538), and the liquid does not solidify again until after standing a considerable time; when very gradually raised from the ordinary temperature up to 200°.—205°. C., so carefully that all of the water is expelled without aqueous fusion of the salt, the residue, or dried alum, is light and porous; should the heat be too low, a glassy mass may be obtained which can not afterwards be rendered porous, and in this glassy condition the alum is said to retain fourteen of its original twenty-four molecules of water.

Crystallized ferrous sulphate contains seven molecules of water; when moderately heated it dissolves in this water of crystallization; between 33°. C. (91.°4 F.) and 90°. C. (194°. F.) the salt loses nearly six molecules of that water, but to expel the sixth molecule requires continued heat at about 120°. to 150°. C. (248°. to 302°. F.), which is liable to partly decompose and discolor the substance; the seventh or last molecule can not be expelled until the heat rises to 280°. C. (536°. F.) which almost certainly destroys a portion of the salt itself.

Sodium phosphate crystallizes with twelve molecules of water; when heated to 35°. C (95°. F.) it begins to dissolve in its water of crystallization, but does not liquefy perfectly until the temperature is raised to about 40°. C. (104°. F.); if now allowed to cool again it solidifies into a mass of a radiated crystalline appearance; above 40°. C. (104°. F.) it loses five molecules of the water; at 100°. C. (212°. F.) *all* of the water is expelled and anhydrous sodium phosphate remains; gradual efflorescence of crystallized sodium phosphate in dry warm air, on the other hand, leaves a residue containing seven molecules of water.

125. The water contained in crystallized salts often materially affects their color.

Thus the sulphate of copper is blue, and ferrous sulphate bluish-green when crystallized; but both are white when dried. Hydrous cobalt chloride is garnet red, but the anhydrous blue.

126. Salts which are decomposed when they come in contact with water may nevertheless contain water of crystallization, as is the case with normal bismuth nitrate.

CHAPTER VII.

CLASSIFICATION OF CRYSTALS.

127. Crystallography is the science of naming, classifying and describing crystals, and of determining their forms.

Theoretically it is a branch of mathematics; practically it serves as an important means of recognizing minerals, salts, and other substances occurring in a crystalline form.

128. The numerous distinct forms which the crystals may assume depend mainly upon three governing conditions: 1, the number of the axes; 2, the angles at which the axes several intersect each other; and 3, the lengths of the axes, respectively.

129. The Six Systems.—The known crystalline forms are classed into six principal groups or systems based upon the number, and the relative inclinations and lengths of their axes.

Five of these systems have three axes; the hexagonal system alone has four axes.

Those systems in which the axes intersect each other only *at right angles* are called *Orthometric systems*. They are the Regular, Quadratic, Rhombic, and Hexagonal Systems.

Those systems in which a part or all of the angles formed by the intersection of the axes are oblique, are called *Clinometric*, and consist of the Monoclinic and Triclinic Systems.

The six crystallographic systems are as follows:

130. The Regular System.—(The Monometric, or Tessular, or Cubic System.)

Axes three in number.

All three axes of equal length.

Axial angles all 90°.

The fundamental forms of this system are the cube, the regular octohedron, and the rhombic dodekahedron.

All the axial and facial angles of the **Cube** are right angles, it has twelve edges, its six faces are perfect squares, and its eight equal solid angles are three-faced. Each of its faces is at right angles to one axis, and parallel with the two other axes. A perfect cube may be built upon its axis by simply placing a plane at right angles against each end of each axis.

Gold, silver, platinum, coper, sodium chloride, potassium iodide, and many other substances crystallize in cubical forms.
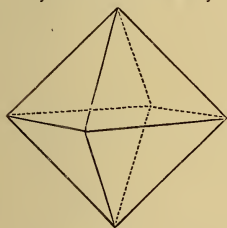
Fig. 19
Regular Octohedron.
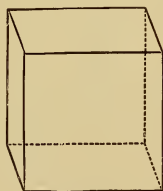
Fig. 20
The Cube.
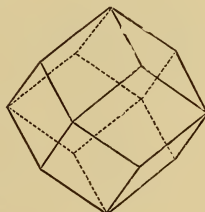
Fig. 21
Rhombic Dodekahedron.

131. The Regular Octohedron is formed by the truncation of the solid angles of the cube, or when each end of each axis is connected by straight lines (or rather, planes) with each end of each of the two other axes.

The figure thus produced is a double, square-based pyramid bounded by eight equal equilateral triangles, has twelve edges, and six four-faced equal solid angles. The angles formed by the edges which are in the same planes, meeting in the apices of the solid angles, are right angles.

Diamond, alum, and magnetic iron ore crystallize in regular octohedrons.

132. By placing a plane in such position that it connects two axes but runs parallel with the third, or by replacing each of the twelve edges of the octohedron, the **Rhombic Dodekahedron** results.

This has twelve equal rhombic faces, and fourteen solid angles.

Garnet phosphorus and cuprous oxide crystallize in dodekahedra.

133. In addition to these forms there are others, less simple. Combinations of the simple forms can be easily imagined. Thus we may imagine a cube and an octohedron with axes coinciding with each other in all respects except that the axes of the cube are somewhat shorter than those of the octohedron; the result would be an octohedron with all its solid angles slightly truncated by the faces of the cube. (See Plate B.)

Galena and lead nitrate show such *compound forms*.

For the purposes of this book, these examples of the manner in which the simple forms may be modified, are sufficient. Similar modifications occur in all the six systems.
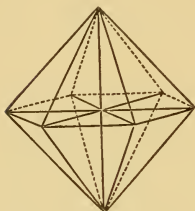
Fig. 22
Double Six-sided Pyramid.
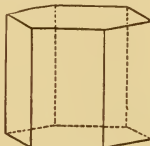
Fig. 23
Six-Sided Prism.
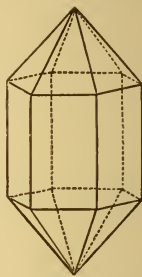
Fig. 24
Quartz Crystal.

134. The Hexagonal System. (The Rhombohedral System.)

Axes four in number.

Three of these axes are of equal length, and they are called the *secondary axes*.

The fourth axis, which is called the *primary axis*, is either longer or shorter than the other three.

The secondary axes are all in the same plane, and cut one another at *angles of 60°*.

The primary axis is at right angles to the plane of the other three.

The fundamental form is the double six-sided pyramid, bounded by twelve equal isoceles triangles, and having eight

solid angles, two of which (one at the apex of each pyramid) are six-faced, the other six being four-faced.

Other important forms are the regular six-sided prism and the rhombohedron. Rhombohedrons are formed by extending alternate faces of the hexagonal pyramid until they cover the others.
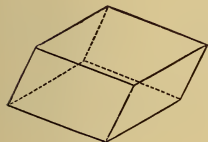
Fig. 25.
Rhombohedron. (Hemihedral.)
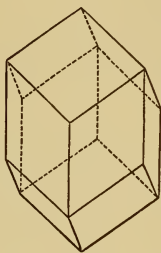
Fig. 26.
Combination of Rhombohedron and Prism.
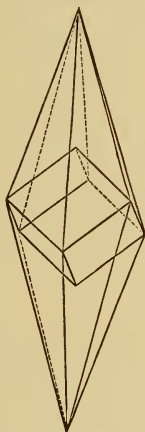
Fig. 27.
Scalenohedron with Inscribed Rhombohedron.

Many substances crystallize in hemihedral forms of this system.

Calc spar, rock crystal, ice and sodium nitrate crystallize in forms belonging to the hexagonal system.

135. The Quadratic System.—(The Dimetric, Square, Prismatic, Pyramidal, or Tetragonal System).

Axes three in number.

The two *secondary axes* are of equal length.

The third or *primary axis*, longer or shorter than the other two.

The axial angles all 90°.

Pyramids of this system have square bases.
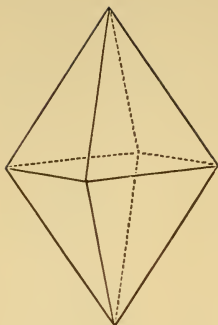
Fig. 28.
Square-based Double Pyramid.
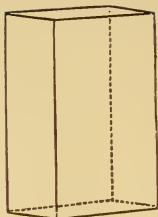
Fig. 29.
Prism of Quadratic System.
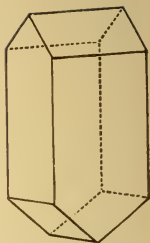
Fig. 30.
Form seen in the Sulphates
of Magnesium and Zinc.

Fig. 31.
Crystal of Potassium Ferro-
cyanide.
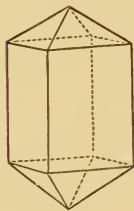
Fig. 32.
Quadratic Prism with
Pyramidal Ends.
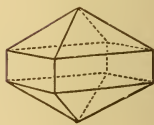
Fig. 33.
Crystal of Stannic Oxide.

The primary forms are the double four-sided, square-based pyramid and the right square prism.

Potassium ferrocyanide, mercuric cyanide, magnesium sulphate and zinc sulphate crystallize in forms of this system.

136. The Rhombic System —(The Trimetric, or Right Prismatic System.)

Axes three in number.

All the axes are of unequal lengths.

The axial angles all 90°.
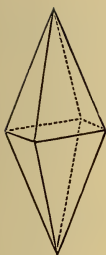
Fig. 34.
Rhombic Pyramid.
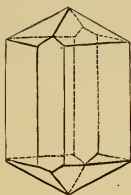
Fig. 35.
Rhombic Prism, with Pyramidal
Ends. (Zinc Sulphate).
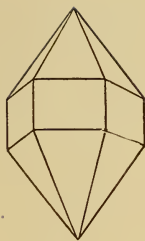
Fig. 36.
Crystal of Potassium
Sulphate.

The fundamental form is the right rhombic double pyramid, or rhombic-based octo-hedron.

Sulphur and potassium sulphate crystallize in forms belonging to this system.
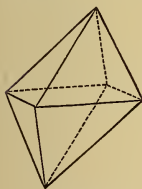
Fig. 37.
Monoclinic Double
Pyramid.
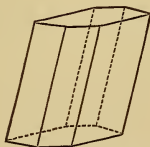
Fig. 38.
Crystal of Sodium Acetate.
(Monoclinic Prism.)

Fig. 39.
Crystal of Cane Sugar.

137. The Monoclinic System.—(The Monosymmetric or Oblique Prismatic System.)

Axes three in number.

All the axes are of unequal lengths.

The two *secondary axes* are at right angles to each other.

The *primary axis* is at right angles to one of the secondary axes, but forms oblique angles with the other.

The primary form is the monoclinic pyramid.

Ferrous sulphate, borax, potassium chlorate, sodium acetate, sodium thisosulphate, sodium sulphate, sodium carbonate and sodium phosphate furnish examples of monoclinic crystals. Cane sugar also crystallizes in forms of this system.

138 The Triclinic System. — (The Asymmetric, or Doubly Oblique Prismatic System.)

Axes three in number.

All the axes are of unequal lengths.

All the axial angles oblique.

This is consequently the least regular of all the systems.

Fig. 40.
Crystal of Gypsum.
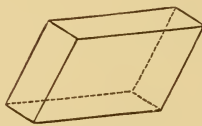
Fig. 41.
Triclinic Prism.
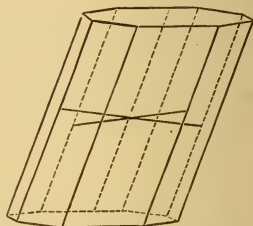
Fig. 42.
Calcium Thiosulphate.

The fundamental form is the triclinic pyramid.

Copper sulphate, potassium bichromate, boric acid, manganous sulphate and bismuthous nitrate crystallize in triclinic forms.

139. *Cubes* belong to the Regular System.

Prisms are to be found in all except the Regular System.

Prisms with rectangular sides belong to the Hexagonal System if six-sided; to the Quadratic System if four-sided. Prisms with oblique angles or rhomboid sides and bases belong to the Monoclinic System, if any two of their axes are at right angles; to the Triclinic System when they have no right axial angles.

Pyramids belong to all of the six systems.

Those with square bases belong to the Regular System if the three axis are of equal length, the faces being then equilateral triangles; to the Quadratic System when one axis is longer or shorter than the other two, the faces being then isoceles triangles. Pyramids with hexagonal bases belong to the

Hexagonal System; their faces are isoceles triangles. Pyramids with rhombic or rhomboid bases belong to the Rhombic System, when all the axes are at right angles; to the Monoclinic System when any two axes are at right angles; and to the Triclinic System when there are no right axial angles.

140. Among the terms used in the pharmacopœial descriptions of crystallic substances, the following terms are also found, all of which explain themselves, viz.: *tabular, laminar, scaly, acicular* (needle-shaped), *feathery*, and *warty* crystals, etc.

CHAPTER VIII.

ADHESION.

141. Adhesion is the attraction which operates between the unlike molecules of different substances in whatever state of aggregation.

It may operate between solids, solids and liquids, or solids and gases; between liquids, or liquids and gases; or between gases.

Dust, soot and mud *adhere* to houses, furniture, clothing, and other solid bodies; the printer's ink adheres to this page by the same force—adhesion; and cements of various kinds are useful on account of their adhesive nature.

142. Adhesiveness.—Many substances are adhesive or sticky; but their stickiness is by no means sufficient evidence of their strength or utility for the purpose of holding solid bodies together. Nor does any one adhesive substance show the same adhesion for all other substances.

143. Dry, hard solids are not adhesive in that condition; but may become so upon being moistened or dissolved, and then the strength of their adhesion is generally greatest upon again drying or hardening in contact with the surfaces to which they are applied.

144. Viscous substances like tar, honey, etc., may be very sticky and yet useless as agents for fixing solids firmly together.

The strong adhesive power of cement, glue, mucilage and varnish, is familiar to you. The best grades of glue and of hydraulic cement have an adhesive strength equal to about five hundred pounds to the square inch.

145. But different kinds of adhesive substances are used for different materials. Cement is used to hold stones together; mortar for stone and brick; glue for wood; mucilage for paper; gum-resins for glass, etc.

Glue adheres to wood but not to metals; pitch sticks to your fingers if they are dry but not to wet fingers; mucilage adheres to paper and cloth, but not to greased paper or cloth.

146. Dry gum (acacia) is not sticky, but a strong solution of gum (mucilage) is remarkably adhesive. Dry resin (common "rosin") is not sticky, but a solution of it in either alcohol or oil of turpentine exhibits a strong adhesion, while a solution of resin in olive oil is sticky but does not constitute a good or strong cement because it does not dry.

147. In all the instances described in the preceding, the adhesion, although a molecular attraction, seems to operate only between whole bodies of molecules and not between the molecules themselves, but the attraction is only between the molecules which form the surfaces of respective bodies which adhere together.

There are, however, very common and important phenomena of adhesion extending to each and all of the molecules of the bodies concerned as in solution (183).

148. Heterogeneous bodies, or mechanical mixtures are sometimes so coarse that we can readily recognize the several *ingredients* in them and thus see that they are composed of unlike masses of molecules, although the ingredients may adhere sufficiently to form one mixed body.

Building mortar made of sand, lime and water, is easily seen to be a *mixture*.

149. Miscibility.—When dry *solids* are mixed with each other, as in "species" or mixed teas and in compound powders, there may be but faint signs of adhesion between the several ingredients.

Liquids between which there is no adhesion are not miscible without the intervention of other substances; thus water and oil, mercury and water, chloroform and water, do not mix (195 and 196).

When *solids and liquids* are brought into contact with each other, the solid is wetted by the liquid if there is any adhesion between them, but otherwise not. Mercury does not wet the bottle containing it, while water does; but water does not wet a greased dish.

150. Pharmaceutically homogeneous mixtures are mechanical mixtures so well prepared, or in which the ingredients are so intimately blended, that they appear as if perfectly uniform, although they may contain solid masses of molecules of different substances.

A well-made ointment containing an insoluble powder may be made so smooth and perfect that the particles of powder can neither be seen nor felt.

A compound powder may be made so uniform that the different ingredients can be recognized only by the aid of the microscope.

In "blue mass" and "blue ointment," if properly made, no globules of mercury are visible to the unaided eye.

An emulsion of a fixed oil can be so thoroughly prepared that no oil globules can be detected in it except with the aid of a good microscope.

Yet, in all of these mixtures the ingredients consist of large bodies of molecules, each particle of each ingredient containing numerous molecules.

151. Mere mixtures may, indeed, sometimes be so intimate as not to be recognizable as mechanical mixtures, except by chemical means.

The air is a mixture of oxygen and nitrogen so perfect that the component ingredients are not to be detected by physical means; but the air possesses the properties of both gases, and is in reality a mere mixture of the molecules of oxygen with the molecules of nitrogen, and the completeness of the mixture is not affected by the proportions.

It is to be remembered that gases diffuse between each others molecules in this intimate manner because their molecules tend to separate from each other (77).

CHAPTER IX.

CAPILLARITY AND OSMOSIS.

152. Capillarity.—If you place a perfectly clean glass plate in a vertical position in a vessel of water, the water will ascend on each side of the plate to a height of nearly one-sixth inch,

being drawn up by the adhesion between the glass and the water, the force of that adhesion being greater than the cohesion between the molecules of water to that extent.

But the column of water above the surface must in this case be supported not alone by adhesion between the glass and the water, but aided by the cohesion in the water itself.

153. If a second plate of glass be placed parallel with and close to the first, the water will rise between the two plates higher than it did when only one plate was used, and, within certain limits, the column of water between the plates will be higher, the nearer the plates are brought to each other.

When the plates are $\frac{1}{100}$ inch apart, the water will rise between them to the height of two inches.
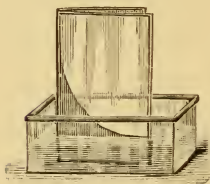
154. If the two plates are so placed as to form an acute angle as shown in fig. 43, the water rises highest at the point where the plates touch each other.

Fig. 43.

155. If a number of tubes of different diameters be placed together in a tumbler half filled with water, the water will rise in each tube a different height in inverse proportion to the diameter of the tube. The smaller the diameter of the tube, the higher the column of water in it. Fig. 44.

Fig. 44.

In a tube of $\frac{1}{100}$ inch diameter the column of water supported by the adhesion between the glass and the water will be four inches high.

156. All of these phenomena are caused by adhesion, and the form of adhesion which causes liquids to rise upon the surfaces of solids is called *capillary attraction* or *capillarity*, because it

is most strikingly evident in tubes of such small diameters as to resemble hairs.

Fig. 45.

157. Capillary attraction is most familiar to us through the action of blotting paper and of lamp wicks. The blotting paper absorbs ink, water and many other liquids by its capillarity. Lamp wicks carry the oil from the reservoir or fount of the lamp to the burner.

158. If a lamp wick or a strip of toweling be placed with one end in a vessel containing a liquid, the other end hanging down on the outside (Fig. 45), it acts as a siphon (297).

159. The reason why a liquid can not easily be poured out of a full tumbler, or other vessel having no lip or flaring rim,
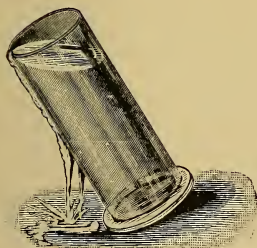
Fig. 46.   Fig. 47.
Illustration of the Utility of the Guiding Rod.

without spilling and without running down along the outside of the vessel, is that the attraction between the liquid and the surface of the vessel draws them together.

To prevent this we may grease the edge or rim of the vessel, to prevent the capillary attraction, or we may use a guiding rod to divert it (Fig. 47).

Lips are formed on graduated glass measures (" graduates "), pitchers,

pans, dishes, mortars, beakers, and other vessels in order to avoid the incon-
venient results of capillary attraction—spilling, and the wetting of the outside
of the vessel.

Lips and guiding rods give the proper directing to the stream.

160.   But capillary attraction is exhibited only when the
liquid wets the surface of the vessel or tube (149).

As water wets glass while mercury does not you will find that water
poured into a small graduate or tube forms a concave surface being drawn
upward along the edges, while mercury, on the contrary, forms a convex
surface.

161.   A dry lamp-wick or dry blotting paper will absorb and convey any
liquid which wets it; but if the wick or paper be saturated with one liquid it
will not afterwards convey another liquid immiscible with the first.   Thus a
lamp-wick wet with water will not draw oil, nor will a wick saturated with oil
take up any water.

162.   In U–shaped tubes such as shown in Figures 48 and
49, mercury not only forms convex surfaces in both branches, but
is depressed in the smaller branch, while water forms concave
surfaces in both branches and ascends higher in the smaller
branch than in the larger.

Fig. 48. Fig. 49.

163.   But not all liquids affected by capillarity rise to the
same height in tubes made of the same material; nor does any
one liquid rise to the same height on one solid as on another.

In a glass tube we find that alcohol does not rise much over one half as
high as water, nitric acid three-fourths as high, but a solution of ammonium
carbonate higher than water does.   On the other hand, mercury rises on lead
and zinc although it does not rise in glass tubes.

164.   It has been shown that liquids do not rise on solids unless the adhe-
sion between the solid and liquid exceeds one-half of the force of the cohe-
sion of the liquid.

165.   If you put a strong water solution of ammonium chloride, or of
lead acetate, in a shallow dish, and allow it to stand sufficiently long, solid
matter will deposit along the edge of the surface of the solution, portions of
the solution will rise by capillary action upon the solid particles and above
them and (by spontaneous evaporation) deposit more solid matter, and this
may continue until a crust of solid creeps over the edge of the dish and con-
tinues on the outside.

166.   In the extraction of soluble matters from plant drugs,
as in making tinctures, fluid and solid extracts, etc., the

menstruum or solvent used is absorbed into the particles of the drug by capillarity. By this force the water, or diluted alcohol, or even undiluted alcohol to some extent, is made to permeate every particle of the powder used.

167. Capillarity is absolutely necessary to vegetation and animal life. In dry seasons water is drawn to the surface of the ground by capillary action; the ascent of sap in plants, and the circulation of the fluids in the tissues of plants and animals is in great measure caused by the same force.

168. Diffusion of Liquids.—Miscible liquids (149) have a tendency to mix with each other, without any stirring or shaking, and even in apparent opposition to the law of gravitation. This tendency is called *diffusion*.

Put some water, colored with red ink or cochineal, into a tall bottle or in a graduate; make a solution of one ounce of washing soda in four ounces of hot water and filter it; then pour the solution slowly through a thistle tube (Fig. 50), into the same bottle keeping the end of the tube at rest near the bottom of the bottle until all of the solution has been added. If you do not have a thistle tube, put the soda solution in the bottle first and then add the colored water, pouring this cautiously and slowly down along the sides of the bottle so that the two liquids will not mix. As the soda solution is denser it will temporarily remain at the bottom under the lighter water. But the two liquids become gradually mixed with each other by diffusion until in the end the mixture is perfectly uniform.

You may perform the same experiment with other liquids of different densities, as alcohol and water, water and glycerin, etc., coloring one of the two liquids used so that the result may be readily seen.

Fig. 50.

The diffusion is uniform only in dilute solutions.

169. A bladder has no visible pores, and indeed, if you nearly fill a dry bladder with water and let it stand in an open vessel, no water will escape *through the membrane*. Water will be absorbed into the substance of the bladder, but no drops of water will appear on the opposite side. If you tie the bladder so tightly near its opening that no water can escape at that point, and then place the filled bladder in a screw press and apply pressure gradually, no water passes out of it until it bursts. You would regard it, therefore, as water-tight.

Parchment paper, also, holds water, although, like a bladder, it is wetted by water and absorbs that liquid into its substance; but it has no visible pores.

170. Yet, when such a membrane is placed between two liquids both

capable of wetting it, currents may pass through the septum in either direction, according to their kind and respective densities.

Cell walls act in the same way.

171. These membranes or septa must, therefore, be porous diaphragms, notwithstanding the fact that no pores can be seen in them even when examined with the highest powers of the microscope.

172. Osmose.—The diffusion of liquids through membranes (as described in the preceding paragraphs), is called *osmose*.

173. Osmose evidently depends upon capillary action (159 to 168).

174. The osmotic currents pass through the membrane in both directions, to and fro, until the liquids in both sides have the same composition. Should the liquids on both sides of the septum be the same from the beginning no currents can be detected; but if they are different and at the same time miscible, osmose takes place and continues until the diffusion has made them perfectly uniform.

175. But denser liquids move more slowly than lighter liquids through the membrane. Hence, the current toward the denser liquid is stronger than the current in the opposite direction.

176. If a bladder is filled with a saturated solution (188), of potassium carbonate (common "potash"), a piece of broom stick inserted in the opening, the neck tied tightly to the stick, and the bladder then immersed in a vessel of water, the current of water passing into the bladder may be so much more rapid than the current of the solution of potassium carbonate passing out of it that the bladder may burst.

177. Osmose may be accounted for by the assumption that organic membranes consist of a network of solid matter, the meshes or pores of which are invisible because filled with water, this water being held with such force that it can not be expelled without destroying the membrane. Liquids miscible with water may thus be passed through the pores by the intersticial water.

178. Substances held in solution in water are capable of passing through organic membranes by osmose (172 to 177). But all water soluble substances do not act alike in this respect;

some substances pass through the septum comparatively rapidly, while others only pass very slowly. It is found that the substances whose solutions diffuse through the septum most rapidly are either crystallizable or somewhat resemble crystallizable substances chemically, while the other water-soluble matters—those that pass through the septum with great difficulty, or very slowly, if at all—include all that solidify in gelatinous masses like glue, gelatin, and gum, and other substanes forming viscous solutions.

179. For these reasons the term *crystalloids* is applied to all substances, which in a state of solution readily diffuse through organic membranes, and the term *colloids* is applied to all water-soluble substances which pass through such membranes with difficulty. It should be remembered, however, that crystalloids are not all crystallizable, and that colloids do not all resemble glue in their external form.

180. The separation of crystalloids from colloids by means of osmotic currents, or by the diffusion of the crystalloids through an organic membrane, is called **dialysis**.

181. It has been found that water will pass through an organic membrane far more rapidly than alcohol.

Fig. 51, represents an apparatus used to demonstrate that fact. Insert a long tube by means of a perforated cork or rubber stopper into a squatty bottle, the bottom of which has been removed. Tie a piece of bladder tightly over the open lower end of the bottle. Fill the bottle and part

Fig. 51.

of the tube with alcohol. Then place the bottle in a shallow dish containing water. In the course of a few hours the liquid will have risen in the tube, and, if sufficient time be allowed, the water will at last have passed through the bladder in sufficient quantity to cause the liquid in the tube to overflow at the top.

182. Dialysis is employed in chemical analysis for the separation of crystalloids from colloids, and also in the arts and manufactures for the purification of products, etc.
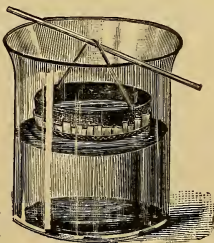
Fig. 52.—A Dialyzer.

CHAPTER X.

SOLUTION.

183. **Solution** is a complete molecular blending of any substance with a liquid, resulting in a clear, homogeneous liquid product.

The product of solution is also called *a solution.*

The liquid employed to produce the solution is called a *solvent.*

From the definition given above it will be seen that solution extends to the molecules; thus the molecules of the substance dissolved are so far separated from each other that the molecules of the solvent lie between them. Solution is, therefore, the most intimate and perfect union that can be effected of any substance with a liquid. It is the result of molecular adhesion. A solution contains no visible particles of solid matter.

184. **Solubility.**—Not all substances can be brought to a state of solution. Thus, no solvents are known for carbon, the metals, and for numerous compounds. The capacity of any substance for being dissolved in a liquid is called its *solubility.* But any one substance may be soluble in one or more liquids, while insoluble in others. Whenever the word "solubility" is used without specifying the solvent referred to, it is understood that *solubility in water* is meant. Thus, when we say that alum is soluble, we mean that it is soluble in water.

A soluble substance may be either solid, liquid or gaseous.

185. **Ratio of Solubility.**—The extent to which any substance may be dissolved in any given solvent is also usually expressed by the word "solubility."

Thus we say that the solubility of potassium chlorate (in water) is about 6 per cent , or about one ounce to the pint

Experience teaches that some substances are insoluble, others very sparingly soluble, others readily soluble, or freely soluble.

186. Solution modifies cohesion and density. When a solid is dissolved its cohesion is diminished, and it is thus rendered liquid. When, on the other hand, a gas is dissolved, the molecules of the gas are brought together, and the gas is condensed and liquefied.

187. The substance dissolved of course always adds to the volume and weight of the solvent.

188. A *saturated solution* is one in which the adhesion of the solvent for the substance acted upon by it is satisfied, or one in which the adhesion between the solvent and the dissolved substance is neutralized or balanced by the cohesion or the tension which oppose it. Such a solution is not capable of dissolving any more of the substance it contains, but may, nevertheless, act as an effective solvent for some other substance.

A saturated solution of potassium nitrate is incapable of dissolving more potassium nitrate, but it can dissolve many other substances.

189. Solution affords striking illustrations of the extreme divisibility of matter. Thus, one drop of a saturated solution of copper sulphate (" blue vitriol ") put into a gallon of water will strike a decided blue color on the addition of a little ammonia water.

A drop of tincture of chloride of iron in a gallon of water will assume a purple color on the addition of a grain of sodium salicylate.

A grain of sugar of lead will make a gallon of water cloudy and on addition of a few drops of diluted sulphuric acid a decided turbidity results.

190. There are two kinds of "solution" spoken of.

True solution, or **Simple Solution**, is a solution in which the molecules of both the solvent and the substance dissolved remain unaltered.

Chemical Solution is a solution in which the molecules of both the solvent and the substance dissolved disappear or are destroyed, other (new) molecules taking their place.

When a piece of sugar is dissolved in a quantity of water, simple solution takes place, because the solution formed contains the molecules of the sugar and the water, and no new kinds of matter are produced. The solution exhibits the sweetness and many other properties of the sugar, and the solution also partakes of the properties of the solvent; in fact, the sugar can be recovered again as solid sugar of the same kind as before by simply evaporating (390) the water.

But when zinc is dissolved in diluted sulphuric acid the solution which takes place is not simple solution but chemical solution, because the resulting liquid does not contain any molecules of zinc (nor any molecules of sulphuric acid, if the acid be saturated with the zinc) but does contain molecules of a salt called zinc sulphate formed by chemical action and which has entirely

different properties from those belonging to zinc. Upon evaporating such a solution you would not get zinc, but the white crystalline water soluble zinc sulphate.

191. A solvent producing simple solution is called a *simple solvent*, or a *neutral solvent*, while solvents producing chemical solution are called *chemical solvents*.

The most common simple or neutral solvents are water, alcohol, ether, chloroform, petroleum spirit, glycerin, volatile oils and fixed oils.

The most common chemical solvents are acids, alkali solutions, and the solutions of acid salts.

192. Substances in solution may be thrown out of the solution or precipitated by adding liquids in which they are insoluble.

Gum (acacia) is soluble in water, but insoluble in alcohol; therefore, if alcohol is added to a solution of gum (mucilage) the gum is precipitated or thrown out of its solution.

Any resin, as, for instance, benzoin, is soluble in alcohol but insoluble in water; hence the benzoin contained in the tincture of benzoin is thrown out of solution on the addition of water.

193. When a water solution of a salt is exposed to such a low temperature that congelation results, the ice formed does not contain the salt.

The water freezes or crystallizes (118), and in doing so must separate from the solution. As the ice forms gradually, the solution may be concentrated by the removal of the portions of ice as soon as they are formed. Plant juices, alcoholic liquids, etc., can be concentrated in the same manner.

194. Solution is a phenomenon of all pervading importance in its uses and results. In animals and plants nutrition would be impossible were it not for the liquefaction by solution of the substances appropriated as food.

The universal application of solution in the arts and manufactures renders it necessary that it should be carefully studied.

195. **Miscible liquids** may be said to be soluble, each in the other.

Thus it may be said that water dissolves glycerin and that glycerin dissolves water, because the two liquids blend perfectly with each other (149).

196. If you have two miscible liquids, A and B, and if A is miscible also with a third liquid, C, it does not follow that B, too, is miscible with C.

Thus, alcohol and water are miscible, and alcohol is also miscible with castor oil, but water and castor oil do not mix at all.

Water is miscible with alcohol, alcohol with ether, ether with olive oil, and olive oil with oil of turpentine, but water does not mix with either ether, olive oil or oil of turpentine; the alcohol does not mix with olive oil or with oil of turpentine, nor the ether with oil of turpentine.

The miscibility of one liquid with another, therefore, affords no indication of its miscibility with a third liquid.

CHAPTER XI.

MOTION.

197. We have seen (60) that "*dynamics* treats of the states and motions of matter in its molar condition, and of the relations and results of molar attraction and repulsion."

We have also read that *Energy* (58) is the power to do work, to overcome resistance, to produce or arrest motion; and that *motion* (59) is a change of place.

Again, *attraction* and *repulsion* were described (35 and 36), and *gravitation* and *weight* were defined (38 to 41 incl.)

The reader is advised at this point to turn back to the paragraphs referred to, and to carefully read them over again.

Remember also that *matter* is anything that occupies space and is affected by gravitation (3 to 6 incl.)

198. All matter is in motion (59), and, therefore, the terms motion and rest are merely relative terms.

The earth itself is in constant motion. It moves around the sun at the rate of 19 miles per second, and at the same time whirls around on its axis at the rate of 1440 feet per second. But when you look at large buildings, or any other objects on the earth's surface it does not occur to you that they are traveling nearly a thousand miles per hour in one direction, and 68,400 miles per hour in another direction, because you are travelling at the same rate yourself, together with all the objects around you.

If to this motion of the globe you add the molecular motions and atomic motion, it will not be difficult to see that no material object in the Universe is ever absolutely at rest.

199. The Laws of Motion.—Sir Isaac Newton pro-
pounded the following "laws of motion," which are universally
accepted and are of the greatest importance:

*1. A body continues in a state of rest or of uniform motion in a
straight line unless forced to change its state by a force external to itself.*
(See **Inertia,** par. 31.)

*2. The change of (quantity of) motion is proportional to force,
and takes place in the straight line in which the force acts.*

*3. To every action there is always an equal and contrary reaction;
or, the mutual actions of any two bodies are always equal and oppositely
directed.*

200. The first law simply declares that matter is entirely
distinct from all force, and that, therefore, matter itself can do
nothing.

201. The second law means that any amount of force, how-
ever small or great, in whatever direction applied, will have its
corresponding effect, no matter what other forces may be at
work simultaneously upon the body. The second law is also
stated in the following words: *A given force has the same effect in
changing or producing motion, whether the body upon which it acts is
in motion or at rest; whether it is acted upon by that force alone or by
others at the same time.*

202. The third law is less easily grasped. In modern phrase-
ology it is merely this: "*Every action between two bodies is a stress.*"

It is literally true that when you strike your fist against a stone, the
stone reacts with equal force. A coat hanging on a hook retains its position
because the hook reacts with a force equal to the pull of the coat. When a
ball is fired from a cannon, the cannon recoils with a momentum (204) equal
to that of the ball, but the backward motion is much less because of the
greater weight of the cannon. If you hold a brick on your hand, the hand
must press upward against the brick with precisely the same force as that
with which the brick presses down against the hand. The brick is attracted
by the earth, and when you turn your hand over and let the brick fall the
earth moves to meet the brick for the attraction between the two bodies is
mutual, but the mass of the earth being immeasurably greater than the mass
of the brick, the earth moves so slightly that its motion is imperceptible. When
a flying bird beats the air with its wings, the reacting force of the air, being
greater than the weight of the bird, causes the bird to rise.

203. The *velocity* of motion refers to the space traversed in a given time.

204. The **Momentum** of a body is the quantity of its motion. It depends upon the mass (7) of the moving body and upon the velocity (203) of its motion.

205. A body of great weight, moving with great velocity, has a greater momentum than a body of less weight moving with the same velocity, or a body of the same weight moving with less velocity.

206. The momentum (204) of a slowly moving freight train is greater than that of a bullet shot from a rifle, and both have a great momentum—the first because of its great weight, the second because of its great velocity.

207. We apprehend danger from the approach of large masses, instinctively associating them with great force, and we move out of their path; but we pay no attention to small bodies moving toward us.

208. A pebble thrown against a heavy plate glass window does not break the glass, but a large stone thrown with the same force will shatter it.

209. A large pestle gently placed upon a piece of alum in the mortar so that the whole weight of the pestle rests on it does not crush the alum, but if the pestle be elevated and then allowed to fall upon the alum, the piece is broken.

210. *Centrifugal force.* is the tendency of a body revolving around a center to continue its motion in a straight line, and thus to move further away from that center. In other words, it is simply the result of Newton's first law of motion (199).

The mud is sent flying from the revolving wheels of a rapidly moving carriage, and when the carriage turns a corner abruptly its tendency to move on in the straight line of its original direction may cause it to be overturned.

211. **The Center of Gravity** of a body is the point at which the whole weight of the body may be supposed to be centered, or that point at which the entire mass of the body may be balanced.

To support any body it is only necessary to support its center of gravity.

212. In a compact body the center of gravity is within the mass; but in a hollow body, like an empty box, bottle, or hoop, the center of gravity is outside of the space occupied by the matter of which the body consists, which is also the case in the arrangement represented in Fig. 54, which you can easily construct with a tumbler or goblet, two table forks, and a match. The forks
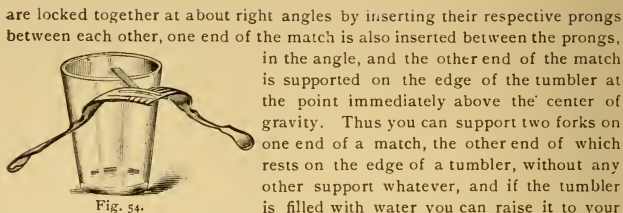
are locked together at about right angles by inserting their respective prongs between each other, one end of the match is also inserted between the prongs,

in the angle, and the other end of the match is supported on the edge of the tumbler at the point immediately above the center of gravity. Thus you can support two forks on one end of a match, the other end of which rests on the edge of a tumbler, without any other support whatever, and if the tumbler is filled with water you can raise it to your lips and drink a portion of the water with the forks still hanging on the end of the match. Fig. 54.

Fig. 54.

In a solid sphere the center of gravity is, of course, the center of the sphere.

213. Equilibrium.—When a body is at rest, the forces which act upon every part of its mass are said to balance each other and are said to be in equilibrium. A body is in equilibrium when its center of gravity is supported.

214. A body is in *stable equilibrium* when supported in such a manner that, when somewhat displaced from its position, it re-assumes the same position as before.

A cone resting on its base is in stable equilibrium.

A body is in *unstable equilibrium* when so supported that a slight change in its position of equilibrium causes it to fall further from that position.

A stick balanced in a vertical position on the end of the finger is in unstable equilibrium.

A cone resting on its apex is in unstable equilibrium.

A body is in *neutral equilibrium* when so supported that it remains at rest in any adjacent position after it has been displaced.

A solid sphere is in neutral equilibrium when resting upon a horizontal plane, and a cone lying on its side is in the same state.

215. The **base** is the side on which a body rests.

The base of support of a table is the figure formed by straight lines connecting the points where its legs touch the floor.

216. The **line of direction** is the vertical line connecting the center of gravity of a body with the center of the earth.

217. Stability.—The broader the base is, and the lower the center of gravity, the greater will be the *stability* of the position of the body.

Hence, a tall stand must have a broad and heavy foot.

If the line of direction fall within the base the body is stable, if the centre of gravity is above and outside the base, or (which is the same thing), if the line of direction be outside the base, the body must change its position.

A ball rolls about easily, especially one of a hard material, like a billiard ball, because when it rests, it rests only upon a point. A cylinder, as a round lead pencil, resting upon a line, also requires but a slight impulse to move it. No elevation of the center of gravity is necessary to start spheres and cylinders moving.

218. Velocities of falling bodies.—All bodies, without regard to mass or kind of matter, fall with equal velocity through space in a vacuum.

A feather will fall as rapidly as a bullet through a vacuum.

But if two bodies of different densities (10), fall through air, the denser body will reach the ground first, because it meets with less *resistance* from the air (199 and 202), than the less dense body. •

219. When bodies fall through a vacuum there is no reaction (199), or resistance; but reaction and resistance are always met when bodies fall through any fluid (80).

220. If several bodies, all consisting of the same kind of matter, but of different weights, as for instance, a number of iron balls of different sizes, be dropped at precisely the same time from a great height, they will all reach the ground at precisely the same time, the smallest ball as soon as the largest.

Twenty horses together can not run any faster than one horse alone.

221. The fact that a dense body, like a small glass bottle, falls to the floor more rapidly than a cork of equal bulk, makes it appear as if heavy bodies fall faster than light bodies; but a quart bottle will fall no faster than a homœopathic vial, and *in a vacuum* corks and bottles will fall with equal velocity.

222. The falling of bodies to the earth is the result of gravitation (38), which affects all matter alike. While gravity is directly proportional to mass (7), and, therefore, a lead bullet must be attracted to the earth with greater force than a feather, the greater force of gravity acting upon the bullet has more work to perform, or has to move a greater load.

For the greater force to do the greater work requires as much time as for the lesser force to do the lesser work (58).

223. As gravitation operates continuously upon matter, being a *constant force*, a falling body acquires *accelerated velocity* in the act of falling.

224. A body starting from a condition of rest to fall of its own weight travels about 4.9 meters in one second.   In the start, of course, it had no velocity, but as it began to move or have velocity, that velocity increased uniformly; its velocity at the end of the first second is such as would, if uniformly continued, carry the body a distance of 9.8 meters during the next second.   And as gravitation continues its pull without the least change, the velocity of the falling body continues to increase, so that instead of traversing only 9.8 meters the second second, the body falls through 14.7 meters, or three times the distance it traveled in the first second.   For the same reason the body travels through 24.5 meters during the third second, or 5x4.9; during the fourth second it falls 7x4.9 meters, etc.
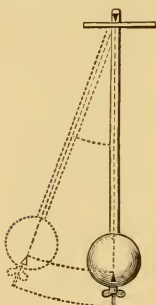
Fig. 55. A Pendulum.

225. A **Pendulum,** Fig. 55, is a weight suspended from a fixed point so as to swing (or "oscillate") freely to and fro, alternately by momentum and gravity.

The most common form of a pendulum is a flexible steel rod loaded at the bottom with a heavy piece of metal called the *bob.*

The bar or rod of the pendulum being in a vertical position, the center of gravity is at the lowest possible point.   The pendulum is then at rest.   But when the bob is moved upward and to one side, and then released, the pendulum is carried back to its vertical position by gravity, and inertia (31) carries it beyond that position, raising the bob again on the opposite side, until gravity stops the motion and pulls the bob down again.

226. Pendulums of the same length perform an equal number of oscillations at the same place in the same time.

227. The times of vibrations of different pendulums at the same place are proportional to the square roots of their lengths.

Thus, if one pendulum is four times as long as another, the time of vibration of the longer pendulum will be twice as great as the time of oscillation (or of vibration) of the shorter one.

228. The times of pendulums of the same length in different places are inversely proportional to the square root of the intensity of gravity.

229. The Seconds Pendulum.—The length of the Pendulum performing its oscillations in seconds of time in the latitude of London (at the Greenwich Observatory) at the level of the sea is 39.13929 inches. At the equator its length is 39 inches, and near the poles it is about 39.2 inches.

230. The pendulum illustrates well the two kinds of energy— *energy of motion* and *energy of position.*

When at rest the pendulum exhibits no energy whatever. But in raising the bob to one side, or elevating its center of gravity, we impart to it the *potential energy* (or energy of position), which remains stored up as potential energy as long as we hold up the center of gravity, but becomes changed into *kinetic energy* (or energy of motion) as soon as we let the bob fall.

231. Potential Energy, then, is stored up energy, which is not doing work, but which has the ability to do work whenever released.

A body, as a weight, lifted up from the earth, being pulled downward by gravity, has the ability to fall as soon as its support is removed, and can then do work. The body of water in a dam has the power to move a water-wheel whenever allowed to fall upon it. A spring when wound up has power to turn machinery and to do other work. A stretched rubber band, a bent bow, also possesses potential energy of position.

232. Kinetic Energy, or energy of motion, or actual energy, is energy in the act of doing work.

Thus it is the energy of the up-lifted weight after its support has been removed; of the water falling on the water-wheel; of the spring, of the stretched rubber band, and the bended bow, when released.

CHAPTER XII.

WORK AND MACHINES.

233. Units of Work.—In measuring work done the unit in which the work is expressed is the work done in lifting a given weight through a given vertical height.

The English unit is the *foot pound*, which means the work necessary to raise one pound one foot; the metric unit of work is the *kilogram meter*, which means the work done in raising one kilogram through one meter.

234. But in order to estimate the power of any man, animal or machine to do work, it is not enough to determine the weight which can be moved by each, and the distance through which that weight can be moved; it is also necessary to determine the time required to do that work.

235. The work of carrying 100 pounds 100 yards is the same as the work of carrying 10 pounds 1,000 yards; and that work is the same whether it be done by a man, a horse, or an engine, or whether it be done by one man or several men; it is the same amount of work, too, whether it be done in an hour, a day, a week, or a year. But the *rate of work* can only be estimated by taking into account the total amount of work done by any given agent in a given time. The rate of doing work is usually expressed in *horse-power*.

236. It is assumed that a strong horse is able to perform 33,000 foot-pounds of work in one minute; therefore that is the meaning of the term *horse-power;* thus 1 horse-power equals 33,000 foot-pounds per minute, and an engine of 20 horse-power is one capable of doing 660,000 foot-pounds of work per minute.

237. As the momentum of a body is the product of its mass by its velocity (204), and as a body gains accelerated velocity when acted upon by a constant force (223), it follows that when a body falls from a greater height it has greater momentum at the end of the time of motion.

A weight dropped from a height of nine yards will strike a bed of clay with three-fold velocity and penetrate to nine times the depth into the clay as compared with the work of the same weight when dropped from a height of only one yard.

The work done by a moving body will vary as the mass and as the square of the velocity.

238. A *machine* is a contrivance by means of which a given power may be advantageously used to perform a given amount of work.

239. A **Lever** is an inflexible bar capable of being freely moved about a fixed point or line called the *fulcrum* at which the lever is supported. The *power* and the *weight* act on this bar at different points. A lever has two arms—the *power-arm*, and the *weight arm*.

240. There are three kinds of levers, differing from each
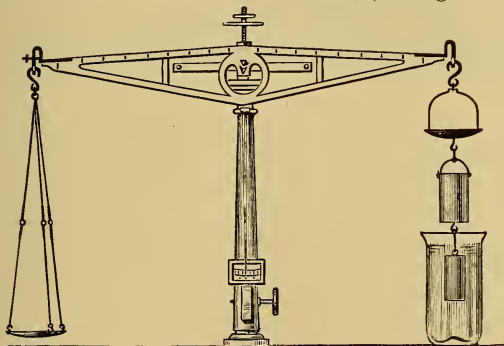
Fig. 56. A Balance.

other according to the relative positions of fulcrum, power and weight.

A "*lever of the first kind*" (see Fig. 56) has the fulcrum between the power and the weight, as in the steel-yard, or in a crow-bar, a balance, scissors, etc.

A *lever of the second kind* has the weight between the power and the fulcrum, as shown in cork-squeezers, nut-crackers, tobacco-cutters, an oar, etc.

A *lever of the third kind* has the power between the weight and the fulcrum, as in fire-tongs, sheep-shears, and in the treadle of a lathe.

241. *The statical law of the lever.* The product of the power

multiplied by its distance from the fulcrum is equal to the product of the load multiplied by its distance from the fulcrum.
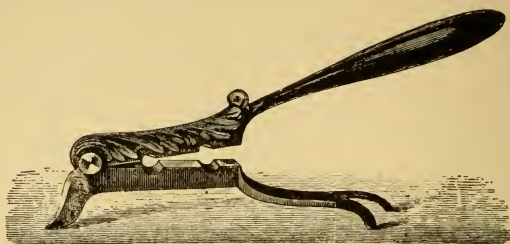
Fig. 57. Cork Presser. A lever of the second kind.

242. Thus in a lever of the first kind, four feet long, if the load be one foot from the fulcrum, a power of one pound will balance a load of four pounds since 3 x 1 equals 1 x 3.

243. In a lever of the second kind four feet long with the load one foot from the fulcrum, a power of one pound will balance a load of four pounds, for in this lever the power will be four feet from the fulcrum.

244. With a lever of the third kind, of the same length as before, if the power be applied one foot from the fulcrum, a power of one pound will balance a load of only one-fourth pound for in this case the load is four feet from the fulcrum, and 1 x 1 equals 4 x ¼.

245. The Balance is a lever of the first kind (240), with two equal arms. (Fig. 56).

The center of gravity of this lever must be a little below the edge of the fulcrum. This brings it to such a state of stable equilibrium, that it will readily return to a horizontal position.
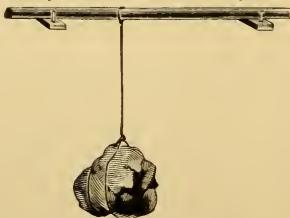
Fig. 58.

246. A load carried on a lever between two supports will be equally divided between the two carriers only if it be equidistant from the two points of support. If, as shown in fig. 58, the load be placed only two feet from the first support and four feet from the other, the load weighing thirty pounds, the first support carries twenty pounds of the load and the other only ten.

247. **A Pulley** consists of a wheel turning upon an axis and having a cord passing over its grooved circumference.

A single pulley as shown in fig. 59 does not afford any increase of power but only a change of direction; but when two or more pulleys are used together as shown in figs. 60 and 61 a greater load may be lifted with less power, but also with correspondingly less velocity. In the machine represented by fig. 60 it is evident that the hook supports one-half of the load and the hand pulls the other half up, but to raise the load one foot the hand must pull up two feet of the cord, for *each section* of the cord carrying the load must be shortened one foot to raise the load one foot. If the hand, therefore, lifts 10 pounds two feet, a load of 20 pounds will be raised one foot.

Fig. 59.   Fig. 60.   Fig. 61.

With a combination of several pulleys the load which can be raised will be still greater in proportion to the power applied, and the velocity with which the load is raised will be proportionately lessened.

248. **The Inclined Plane.**—The power required to support a load on an inclined plane is to the load as the vertical height of the plane is to its length.

Thus, if the plane is twice as long as it is high, a power of 100 pounds will support a weight of 200 pounds.

249. The **Wedge** is a movable inclined plane, or two inclined planes united at their bases.

250. The **Screw** is a cylinder with a spiral groove or ridge winding about its circumference. It is, in fact, simply a spiral inclined plane.

The spiral ridge is called the *thread* of the screw, and this works in a *nut* in which there is a corresponding groove in which the thread fits.

One full turn of the screw will lift a weight through the distance which separates the threads.

The weight moved is to the power required to move it, as the circumference described by the power is to the distance between the threads.
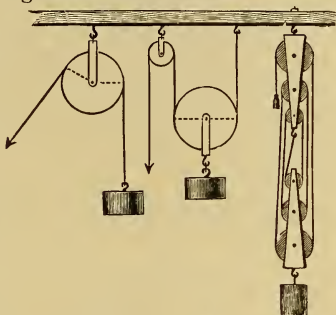
Thus, a power of thirty pounds applied at the end of a lever two feet long, acting on a screw, the threads of which are $\frac{1}{20}$ inch apart, will lift a weight of 45,300 pounds.

Hence the great power of the screw press.

251. **Friction** is the resistance which a moving body encounters from the surface against which it moves.

A perfectly smooth surface can not be made, and despite lubrication and other means to diminish the resistance, heat is developed by the friction, and the mechanical energy is thus converted into molecular motion. Adhesion is doubtless closely related to friction.

252. **Hydrodynamics** is the dynamics (197) of liquids. **Pneumatics** is the dynamics of air and other gases.

CHAPTER XIII.

HYDRODYNAMICS.

253. **Liquids transmit pressure equally in all directions.**—If pressure is applied from without upon water contained in a closed vessel, that pressure is transmitted by the water in every direction, upward as well as downward and outward, with the same force as originally applied. That force is proportional to the surface to which it is applied.

Thus, if a pressure of one pound be applied to the water through a tube, the opening of which measures one square inch, then there will be a pressure communicated to the sides, top and bottom of the vessel amounting to one pound to every square inch of their surface. (See also paragraph 257.)

254. **The Bottom Pressure.**—Every molecule at the surface of a body of liquid presses upon the molecule next below it, and this next molecule not only transmits the pressure exerted by the upper molecule, but adds to that pressure its own weight, and so on downward through the whole depth of the liquid. The pressure thus increases with the depth, and if

the liquid be contained in a cylindrical vessel with perpendicular sides and horizontal bottom, the pressure upon that bottom is equal to the weight of the whole body of liquid. But in vessels contracted at the top the bottom pressure is greater, and in a vessel with a wider top the bottom pressure is less than the weight of the whole body of liquid, because *the pressure depends upon the area of the bottom and the perpendicular height of the water* without reference to the shape of the vessel.

" Pressure percolators " of various kinds are constructed on this principle.

255. The Lateral Pressure.—As the pressure is transmitted equally in all directions (253) and at the same time added to in proportion to the depth of the liquid, the pressure on the sides of the vessel is equal to that exerted on the bottom of it only at the edge of the bottom. Midway between the bottom and the surface of the liquid the average pressure is only one-half as great as at the bottom, being always proportional to the depth. At the surface there is no lateral pressure because there is no depth there.

256. Liquids seek their own level.—When placed in communicating vessels, as in a U-shaped tube, liquids rise to the same level in the different vessels or in the several branches or tubes of the same vessel.

As popular expression puts it: "water seeks its own level." Artesian wells operate on this principle, and " water towers " furnish the pressure by which water is supplied through pipes to whole cities, to high buildings and fountains in public parks.

257. The "Hydrostatic Paradox."—Since the transmitted pressure is proportional to the surface to which it is applied (253), it follows that in a vessel with two communicating tubes, one larger than the other, both tubes being provided with tightly-fitting pistons, as shown in fig. 62, a downward
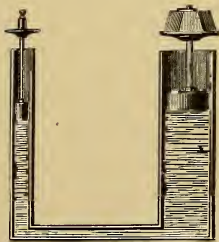
Fig. 62. Hydrostatic Paradox.

pressure applied upon the piston of the smaller tube, *a*, will pro-
duce greater upward pressure upon the piston in the large tube,
b, the pressure being proportional to the area.

   If the area of *a* be 1 square inch and that of *b* 16 square inches, then a
downward pressure of 1 pound on *a* will produce an upward pressure of 1
pound to each square inch upon *b*, and 1 pound placed on the piston at *a* will
lift 16 pounds on the piston at *b* (34).
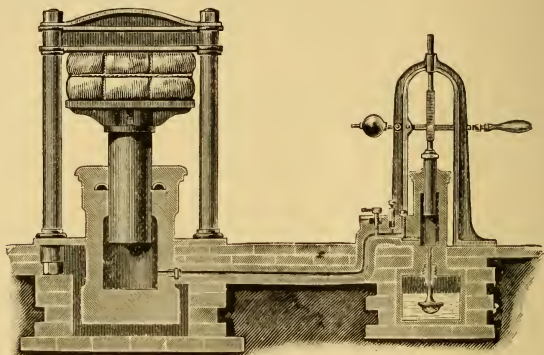
Fig. 63.   A Hydraulic Press.

   258.   The Hydrostatic or Hydraulic Press is based upon
the principle explained in paragraph 257.

   The "Hydrostatic Press" (Brahma's Press) consists of two cylinders
communicating with each other by a tube, as shown in fig. 63. The pump
piston working in the smaller cylinder produces, by the arrangement of the
valves below, a downward pressure which raises the large piston in the other
cylinder.   The distance of the upward movement of the larger piston will bear
the same relation to the distance of the downward movement of the smaller
piston as the pressure on the smaller bears to the pressure on the larger piston.
If the area of the water pressing upward on the large piston be one hundred
times as great as that of the water pressed downward in the smaller cylinder,
the large piston will be raised only $\frac{1}{100}$ foot, while the small piston is pressed
down a distance of 1 foot.   Thus, on one side 1 pound is moved 1 foot, and on
the other side a weight of 100 pounds is moved $\frac{1}{100}$ foot, the work done being,
therefore, the same on both sides (235 and 257.)

Hydraulic presses are much employed in the arts and manufactures, and may be seen in the laboratories of many manufacturing pharmacists and chemists, where they are used to press out liquids contained in wet masses of solid matter, etc.

259. The Law of Archimedes.—A body immersed in any liquid or gas *is buoyed up* (*or pushed in an upward direction*) *with a force equal to the weight of its own volume of the liquid or solid in which it is immersed.*

This principle is one of great importance and wide application. The upward pressure produced by liquid and gaseous media, upon bodies immersed in them is termed *the buoyancy of fluids.*

260. In Fig. 64 we represent a cubical solid immersed in water. Every portion of the surface of the cube is subjected to the pressure which the body of water exerts in every direction, and which is proportional to its depth. The lateral pressure is equal on all sides (255), and therefore will have no tendency to move the solid in any horizontal direction. The pressure downward exerted upon the upper surface of the cube is, however, less than the pressure upward

Fig. 64.

produced upon its under surface, because the pressure of the liquid increases with its depth (254). The exact difference between the downward pressure from above, and the upward pressure from below, is, in fact, exactly equal to the weight of a column of water having the same base and the same height as the solid (254). In other words, the upward pressure is greater than the downward pressure, by the weight of the liquid displaced by the solid. The solid, of course, displaces its volume of liquid.
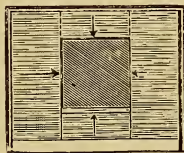
261. Hence the principle of Archimedes is also stated as follows: *A solid immersed in any fluid* (*liquid or gas*) *loses in weight an amount equal to the weight of the fluid displaced by it.*

If a cubic inch of lead be weighed in a vacuum its true weight will be obtained; if it be weighed in air its *apparent weight* (45) will be less than its *true weight* (44) by the weight of a cubic inch of air; if it be weighed in water, its apparent weight will be still less, the difference from the true weight being now the weight of a cubic inch of water, which is heavier than a cubic inch of air.

262. If the cubic inch of lead be weighed first in air, and then successively suspended and immersed in olive oil, oil of turpentine, glycerin, syrup, and sulphuric acid, the weights obtained will all differ from each other, because

all these substances differ in density (10) and specific weight (47). The lead will accordingly be found to weigh as much less in olive oil than it weighed in air, as the weight of a cubic inch of olive oil; in the other liquids, the loss of weight of the cubic inch of lead will appear to be equal to the weight of a cubic inch of oil of turpentine, glycerin, syrup, or sulphuric acid, respectively.

263. There is, of course, no actual *loss of weight* of the solid in the examples given in the preceding paragraph, for matter can not lose weight. The so-called "loss of weight" is simply *apparent*, and instead of representing a loss of weight it represents the effect produced by the *buoyancy* in the liquid or gas in which the solid is placed.

264. The Hydrostatic Balance.—A balance so constructed as to facilitate the weighing of solids suspended in liquids is called a *hydrostatic balance*.

One form of it is seen in fig. 56. At least one of the stirrups is short, and to the support for the pan is attached a little hook from which the solid is suspended by means of a thread or wire.

265. As all our ordinary weighing operations are performed in the air, and not in a vacuum, it follows that the results are not true, the weight found by weighing in the air being less than the true weight by the weight of the air displaced by the body weighed.

266. Our weights are constructed so as to show the "weight in air" and not "true weight," and it accordingly follows that a pound-weight made of brass is necessarily in reality heavier than a pound-weight made of platinum, for the metal called platinum is about three times as heavy as an equal volume of brass, and, therefore, one pound of the alloy we call brass is about three times as bulky as platinum. Hence, when used in air, the brass pound and the platinum pound balance each other perfectly, or have the same weight (apparently), but if weighed in a vacuum the brass weight would be found to be heavier than the other. Had the brass weight been so made as to represent a pound of brass weighed in a vacuum, and the platinum weight to represent a pound of platinum weighed in a vacuum, then, when placed on the opposite pans of the balance (or "pair of scales") the platinum weight would go down and the brass weight up, and it would be necessary to increase the size of the brass weight or diminish the platinum weight to restore the balance to equilibrium in the air.

The saying that "a pound of feathers is heavier than a pound of lead," is, therefore, in one sense correct.

267. Heavy bodies sink in lighter fluids (whether liquids or gases), and **light bodies float** in heavier fluids.

This will be readily understood upon a little reflection, for the upward pressure upon the immersed body caused by the buoyancy of the fluid is exactly measured by the weight of the fluid displaced (259 and 260), and if that weight is less than the weight of the solid itself the solid will sink by virtue of its greater weight following the law of gravitation (38), but if the solid weigh less than its own volume of the fluid it must of necessity rise, or be pushed upward, or float on the surface of the fluid in which it is placed.

268. If the solid and the fluid in which it is immersed are of equal density, equal volumes having equal weights, then the solid will neither sink nor float but will remain at rest in any position in which it may be put in the body of the fluid.

269. Camphor floats on water, but sinks in alcohol. Wax floats on water, but if alcohol be gradually added to the water, the wax will sink as soon as enough alcohol has been added to render the density of the liquid less than that of the wax.

270. A floating body displaces its own weight of the fluid.—A piece of wood floating on water is depressed into the water just far enough to occupy a space below the surface which would be filled by its own weight of water.

If the wood weighs one pound it sinks down far enough to push away, or displace, or occupy the space of one pound of water, below the surface. Boats displace their own weight of water; when empty the boat displaces but little water and rides lightly, but when loaded it sinks deeper as its load increases, and may be loaded so heavily that the weight of the boat with its load is greater than a body of water of the same bulk, and then the boat founders.

271. An "empty" bottle floats on water because the bottle and the air it contains weigh less than the same volume of water; but the same bottle, filled with water, sinks.

272. Since a floating solid sinks down just far enough to displace its own weight of liquid (270), it follows that the solid must descend to a greater depth in light liquids than in heavy liquids.

273. Hydrometers.—Hydrometers are instruments constructed on the principle of Archimedes (259) and operates in accordance with the results of that principle as described in the preceding (270, 271, 272).

274. Fig. 65 represents Nicholson's hydrometer, consisting of a hollow metallic cylinder with a lead basket attached below and a pan supported on an upright wire at the top. The weight of the lead basket brings the center of gravity to that end of the instrument, causing it to descend some distance

below the surface when placed in water, the hollow cylinder above being also a necessary feature of the apparatus, as it is lighter than water, and when pulled down by the lead therefore assumes a vertical position, the whole instrument thus remaining in a stable condition of equilibrium.
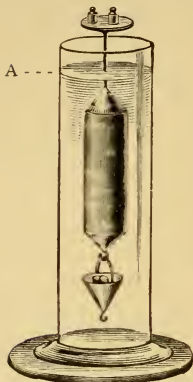
The wire which supports the pan has a mark, A, upon it. As the hydrometer displaces its own weight of whatever liquid it is placed in, and its own weight is known, it is used in the following manner: The sum of the weight of the instrument, and the additional weights necessary to bring the instrument down to the point A, represents the weight of the liquid displaced.

275. Assuming that the hydrometer itself weighs 100 Grams and that it requires 55 Grams more to bring it down in distilled water until the surface of the water coincides with the mark A;

Fig. 65. Nicholson's Hydrometer.

also that it requires 20 Grams (instead of 55) to push the instrument down to A in alcohol. Then the displaced alcohol must weigh 120 Grams, and the same volume of water 155 Grams, and a comparison of the relative weights of equal volumes of these liquids has thus been effected. See " specific weight " (47).

276. Nicholson's hydrometer can also be used to find the specific weight (47) of solids insoluble in the liquid in which the instrument may be immersed.

A piece of the solid substance (not heavier than the difference in weight between the instrument itself and the weight of the water it displaces to the mark A) is put on the pan at the top, and then enough additional weights added to push the hydrometer down to A in water; the solid is then removed and weights substituted for it to bring the instrument down to A again; the sum of the weights used in addition to the solid in the first case, deducted from the total of the weights used in the second case, must give the weight of the solid itself, or the sum of the weights which were necessary to take the place of the solid in the second experiment. Now the solid is put into the lead basket, and the hydrometer replaced in the water and again weighed down to A. As the volume of the instrument below the surface of the water is now increased by the bulk of the solid, the result will be that the instrument is buoyed up by an additional force equal to the weight of a volume of

water equal to the bulk of the solid, and the instrument is at the same time pulled down by the whole weight of the solid. Suppose the solid weighs 7 Grams; then it will require 148 Grams additional weights to sink the hydrometer to A (assuming, as above, that 155 Grams will be necessary to sink it to A in water); when the solid is placed in the lead basket, the instrument will not sink down to A without additional weights on the pan unless the solid is of the same density as water, it will sink deeper if the solid is heavier than water, and not as deep if the solid is lighter. Suppose it is heavier than water, and that it will, therefore, be necessary to take off some of the weights on the pan in order to bring the hydrometer to the fixed depth. If the sum of the weights on the pan be now 147 Grams, or one Gram less than was necessary when the solid was on the pan above the surface instead of in the basket immersed in the water, then the solid weighed 7 Grams in the air, but only 6 Grams under water, and, consequently, its own volume of water weighed 1 Gram.

If the solid be lighter than water it must be tied to the lead basket before submerging it, and we should then find that 155 Grams would be insufficient to send the hydrometer down to the mark. Suppose, in such a case, it requires 156 Grams on the pan; then, the solid weighing 7 Grams, its own volume of water must weigh 8 Grams.

277. The common form of hydrometer is shown in figs. 66 and 67. It is made of glass, the small bulb at one end is loaded with mercury or shot, and the expanded part of the tube above is to keep the instrument in an upright position. The hydrometer sinks to different depths according to the density of the liquid in which it is placed (270), and the point to which it sinks in distilled water at the standard temperature is marked **1**;
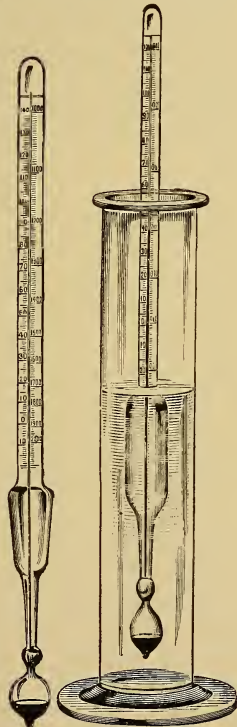
Figs. 66, 67. Hydrometers.

specific weights above and below the unit are indicated on the scale. If the instrument is constructed to show the specific weight of any liquid, whether heavier or lighter than water, the unit (or the specific weight 1) would be situated at about the middle of the stem, but a hydrometer for heavy liquids only has the unit at the top, and one for light liquids at the bottom of the scale.

278. There are several kinds of hydrometers (or areometers), some showing the specific weight, others with scales of arbitrary "degrees" of density, some for heavy and others for light liquids, and several kinds for other special uses, or for particular liquids, as alcohol, milk, syrup, urine, etc.

CHAPTER XIV.

PNEUMATICS.

279. The tension of gases.—We have already seen that molecules of gases repel each other (77).

They, therefore, expand indefinitely if they find space to enter. Hence a small amount of the gas formed by the burning of a sulphur match soon spreads its peculiar penetrating odor through a whole room.

The force with which gases tend to expand is called their *tension* (280).

A liquid boils whenever the tension of its vapor is sufficient to overcome the atmospheric pressure, which always happens at the same temperature if the pressure is the same.

280. Gases are easily compressed. The resistance offered by the gas against compression is its *tension.*

281. Mariotte's Law.—*The volume of a gas is inversely as the pressure it sustains,* at any given temperature.

Thus if the pressure to which the gas is subjected be doubled, the volume of the gas is reduced one half; if the pressure be trebled the volume will be reduced to one-third; if the pressure be reduced one-half the volume of the gas will be doubled, etc.

Gases under equal pressure expand equally for equal increments of temperature (Charles).

A given mass of gas, measuring one liter under the ordinary barometric pressure (287), will measure but one-half liter under the pressure of two atmospheres (287).

282. The densities of gases are in direct proportion to the pressure to which they are subjected (281.)

283. *Atmospheric air* is a mixture of about 79 volumes of nitrogen and 21 volumes of oxygen. It also contains small amounts of water vapor and carbon dioxide. Among the chemical changes which substances are liable to undergo when in contact with the air are, therefore: oxidation, the absorption of moisture when the air is humid; the loss of moisture when the air is dry, and the absorption of carbon dioxide.

284. Atmospheric Pressure.—The air, obeying the law of gravitation, exerts a pressure in every direction upon all bodies in contact with the terrestrial atmosphere. This pressure is equal to the weight of a column of liquid which it will sustain, and is very nearly equivalent to 15 pounds to each square inch of surface, or 1033 Gm. to each square centimeter. At the level of the sea the height of the column of mercury sustained by the atmosphere averages 29.922 inches or 760 millimeters.

As the atmospheric pressure is measured by the height of the column of mercury in the instrument called a barometer, we find the ordinary pressure generally referred to in terms such as "760 millimeters pressure," or "barometer at 760 m. m.," or "barometer at 30 inches."

285. When it is stated that the atmospheric pressure is equal to 30 inches by the barometer, the statement means that the weight of a column of air reaching from the earth's surface, at the level of mid-tide, to the upper limit of the atmosphere, equals the weight of a column of mercury 30 inches in height, the columns of air and of mercury being of the same area at the base. Hence it will be easily understood that the atmospheric pressure on high mountains, where the column of air is of less height, must be less, or must be balanced by a shorter column of mercury. It is further to be considered that the air is of greater density nearer the surface of the earth than higher up. At a height of 4,355 meters above the level of the sea, the barometric pressure is only 380 millimeters, or one-half the average pressure at the level, or the pressure of one-half atmosphere.

286. The amount of moisture contained in the air also effects its density and pressure. The barometer rises with the humidity of the air, and falls when the moisture condenses and descends as rain or snow. As the humidity depends upon the temperature and movements of the atmospheric strata, the barometer indirectly indicates changes in the weather.

287. Atmospheric pressure is also called barometric pressure.

The ordinary atmospheric pressure, balanced by a column of mercury 760 millimeters (30 inches) in height, is "the pressure of one atmosphere;" the pressure of twice as high a column of mercury represents "the pressure of two atmospheres," etc.

288. Weight of the Atmosphere. The atmosphere must weigh about six quadrillion tons, for it equals a layer of mercury covering the entire surface of the globe to the depth of 30 inches, and the specific weight (47) of mercury is 13.6. The air in a room 12½ feet long, 10 feet wide and 10 feet high weighs nearly 100 pounds.

289. But the pressure of the air, which amounts to about 15 pounds to the square inch, is not a *downward* pressure. As in the case of liquids it is a pressure distributed in every direction. (253 to 255.)

All bodies on the earth's surface sustain this pressure. The human body, which has a surface of about 2,000 square inches, must, therefore, sustain a pressure equal to about 15 tons, but we do not feel it because it is precisely what is required for our well-being. Were this pressure to be removed the result would be destructive to us.

290. The weight of a body is in no degree added to by the pressure of the atmosphere.

In fact, we have already learned that all bodies are pushed upward when surrounded by, or immersed in, the air.

291. The Barometer.—Figure 68 represents an instrument called a barometer. It is designed to indicate the atmospheric pressure.

The tube, closed at one end, is filled with mercury and then inverted in a vessel also containing mercury. In the ordinary barometer the lower end of the inverted tube is expanded and bent upward, which renders a separate vessel for the mercury superfluous. The mer-

Fig. 68.

cury runs out until the column remaining in the tube measures 29.922 inches, or 760 milimeters. This proves that a column of mercury of that height balances a column of air of the same diameter reaching through the whole atmosphere from the level of the sea as far up as the atmosphere reaches.

292. Height of the Atmosphere.—It was formerly supposed that the atmosphere was about 45 miles high; but it is now considered probable that it is at least 100 miles.

But, as the height of the mercury of the barometer is only 15 inches when the instrument is taken upon a mountain 3½ miles above the level of the sea, it follows that one-half of the whole ocean of air contained in the atmosphere must lie within a distance of 3½ miles from the earth's surface.

293. A column of water equal to the atmospheric pressure would measure 34 feet, the mercury being 13.6 times as heavy as water.

294. The *pneumatic inkstand*, represented by fig. 69, operates upon the principle that the atmospheric pressure sustains the ink in the inkstand. Whenever the ink in the tube of the bottle comes below the level of the curve a bubble of air enters and forces a portion of ink out into the tube.

Fig. 69.

Fig. 70.

295. Fig. 70 also illustrates the pressure of the atmosphere. If you fill a tumbler with water and place a thick sheet of paper over the top, pressing down the paper tightly, and then cautiously invert the tumbler, the water will not run out because atmospheric pressure upward keeps the paper in its place and prevents the entrance of air into the tumbler.

296. In a PIPETTE, which is the name of the instrument shown in figs. 71 to 75, the atmospheric upward pressure prevents the liquid in the tube from running out.
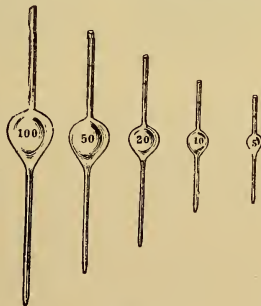
Figs. 71 to 75.

Plunge the instrument into a vessel of water, holding the long tube vertically; when the bulb is filled, close the upper end with the finger, and then withdraw the pipette out of the vesse.. The water remains in the pipette. Now take the finger off the upper end of the tube so that air can enter; there will then be atmospheric pressure from above as well as from below, and, consequently, the water will run down by its own weight.

297. The Siphon.—Another very useful instrument, operating by atmospheric pressure, is the familiar *siphon*. It consists of a bent tube, open at both ends, with one limb longer than
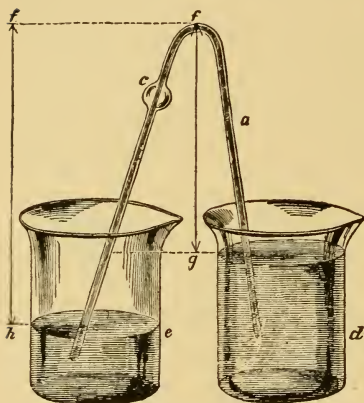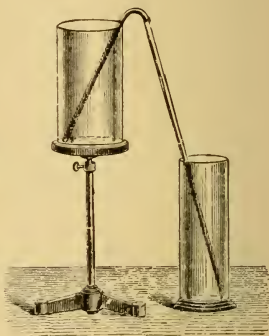
Fig. 76.　　Fig. 77.

the other. The tube may be rigid, as when made of glass or of wood or metal; or it may be elastic, as when consisting of rubber hose. If the short limb be immersed in a vessel of liquid and the whole tube filled with liquid by suction at the end of the longer limb, the weight of the liquid in both limbs would tend to cause a downward flow; the atmospheric upward pressure would prevent the liquid from running out if both limbs of the syphon were of the same length; but as one limb is longer the weight of the liquid in that limb is greater than that of the liquid

in the other limb, and hence the liquid in the longer limb descends while the atmospheric pressure upon the liquid in the vessel forces the liquid up into the shorter limb, since otherwise there would be a vacuum in the siphon, which can not be.

298. To start the syphon it may be filled with the liquid, both ends being closed with the finger ends before placing it in its position, with the short limb in the vessel containing the liquid, and the longer limb in the vessel into which the liquid or a portion of it is to be transferred.

299. The syphon will continue to run until the level of the liquid in the vessel in which the shorter limb is placed descends below the end of the tube, or until the level of the liquid in both vessels coincide should they be so placed as to lead to that result. The end of the limb from which the liquid flows must always be below the surface of the liquid in the vessel from which the current comes.

300. Spritz bottles are made as represented by figs. 78 and 79. Air is blown into the bottle through the tube A and the pressure thus brought to bear on the surface of the water causes a stream to flow through B.

Any ordinary wide-mouthed bottle, with a well-fitting stopper twice perforated for the glass tubes, may be used. The end of the glass tube B should be drawn to a point so as to contract its orifice enough to produce a small stream.
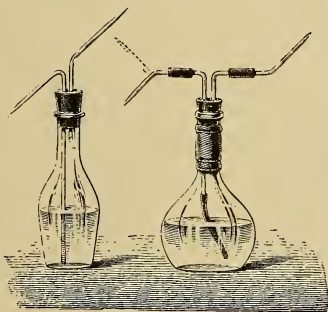
Figs. 78 and 79.

301. Atomizers consist of two tubes placed in such a position relative to each other that a jet of air blown through one of them passes over and near the mouth of the other. One is the blast tube, the other the suction tube dipping into a bottle of liquid. A strong current of air blown through the blast tube carries the air along its path with it so as to cause a rarefaction in the other tube, diminishing the atmospheric pressure in it so that the atmospheric pressure in the bottle will raise the liquid to the mouth of the tube where the current of air from the other tube will blow it into fine spray.

302. Vacuum.—Space void of matter is called *vacuum*. The space above the mercury in the barometer tube is the most per-

fect vacuum that can be produced; it is called the *Torricellian vacuum*.

But a closed vessel may be deprived of nearly all the air it contains by means of an air pump, and in certain pharmaceutical processes a vacuum apparatus, vacuum pans, etc., are employed with the view to remove atmospheric pressure and to avoid the chemical changes liable to result from contact with the constituents of air.

303.   The Air Pump.—Fig. 80 represents an apparatus for removing the air from a closed vessel, the sections of its principal parts being shown in fig. 81.

"The receiver, R, is connected with the cylinder, C, by a long bent tube, terminating in a horizontal brass plate. The mouth of the receiver and the
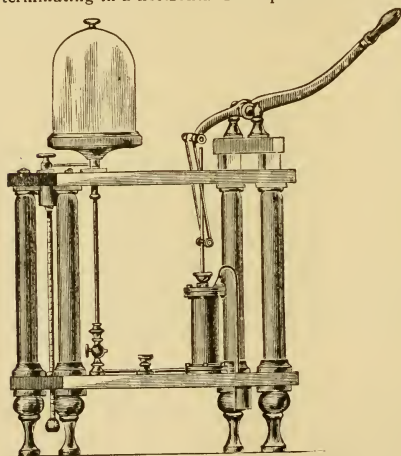
Fig. 80. Air Pump.

surface of the brass plate are carefully ground so as to bring them in contact at every point. The edge of the receiver is greased, so as to make the joint as tight as possible."

"When the piston P is raised from the bottom of the cylinder, the external air closes the upper valve; the air in the receiver expands, opens the lower valve and fills the cylinder. When the piston is depressed, the lower valve closes, and the air in the cylinder is forced through the upper valve out into the atmosphere. As the piston again rises, the upper valve is closed, the lower valve opens and the confined air expands into the cylinder. At every ascent and descent of the piston, a portion of air is removed from the receiver, and this process may be repeated until the tension (279) of the air remaining is not sufficient to lift the lower valve. The receiver is then said to be exhausted."
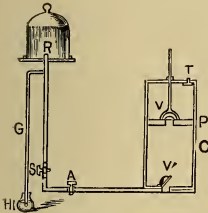
Fig. 81.

"The tension of the air in the receiver is measured by a gauge which consists of a bent tube leading from the receiver to a vessel of mercury, H. The external air forces the mercury up the gauge in proportion as the tension of the air in the tube is diminished. If the exhaustion were perfect, the mercury would rise to about 30 inches. The height of the gauge indicates the difference between the pressure of the atmosphere and the tension of the air in the receiver."

"The air pump is also provided with a stop cock, S, fig. 81, to close the communication between the cylinder, and receiver when required. The stopper, A, is used to admit the external air to the receiver. A third valve, T, is usually placed in the top of the cylinder to prevent the external air from pressing on the piston."

304. **The Magdeburg Hemispheres** are two hollow brass hemispheres fitting together by an air tight joint, as shown in fig. 82. When joined together, the air can be exhausted from the globe by means of an air pump. The hemispheres will now be pressed together by atmospheric pressure, or with a force of 15 pounds to the square inch. With a diameter of three inches, the area of the section would be seven inches, and hence it would require a force of over 100 pounds to pull the hemispheres apart.
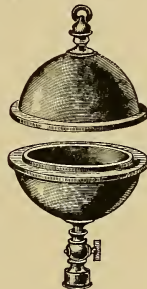
Fig. 82.

CHAPTER XV.

THEORIES AND SOURCES OF HEAT.

305. **Heat** is that mode of molecular motion which may be measured by the expansion of bodies, or which manifests itself, under certain conditions, by the sensations of "warmth" and "cold."

306. "Heat" and "cold" are only relative terms. A room, the atmosphere of which seems "hot" to one person, may seem chilly to another. If you hold one hand in cold water and the other in hot water, and then suddenly transfer both hands to water which is neither hot nor cold, you will find the sensations in your hands reversed. Therefore, cold is not the opposite of heat, but only a lower degree of heat.

307. That heat is a mode of motion is now the universally accepted

theory. Nevertheless, a definition or description of what heat really *is*, or what distinguishes it from other modes of molecular motion, is far more diffi- cult than to describe what heat *does*.

308. Heat expands bodies, or increases their volume, or reduces their density, or overcomes their cohesion, or increases the distances between their molecules—all of which statements mean the same thing.

This effect of heat is resisted by cohesion (55), and may also be opposed by pressure.

309. When heat is applied to any substance a portion of that heat increases the temperature (314) of the substance, while another portion increases its volume, and may, if a sufficient quantity of heat is adduced, turn solids into liquids and liquids into gases.

310. Active heat, or sensible heat is that heat which increases the temperature of bodies and has the power to cause their expansion. It produces upon men and animals the impres- sion of "heat" if the heat motion is rapid, or of "cold" if the motion be less rapid. Having the power to expand bodies it causes the mercury in the thermometer (321) to rise. It is energy in the kinetic form (232).

311. Latent Heat is that heat which has performed the work of expanding the volume of matter and which keeps up this expansion. It performs "interior work" in separating the molecules of the body from each other, and while performing that work can not at the same time do other work, and it, therefore, can not cause the mercury in the thermometer to rise. Latent heat is a form of potential energy (231).

Heat rendered latent is, of course, not lost or destroyed (34 and 67). It can be released again, or recovered, in precisely the same amount of energy, or as active heat, by the compression of the body it expanded.

312. If a quantity of broken ice be placed in a dish and the dish placed over the fire, the ice will melt, but a thermometer placed in the mixture of water and ice will not vary its indication of temperature; the mercury will remain at zero C. (32° F.) until all the ice has been melted. If the heat be contin- ued the temperature of the water will now, since the ice has all been melted, rise until it reaches 100° C. (212° F), and there it will stop again; the water will now boil and the temperature will remain stationary until the water is vaporized,

and the vapor formed will be found to have the same temperature as the boiling water.

Why does not the fire under the vessel warm the contents above 0° C. until after all the ice is melted? Why does it afterwards raise the temperature of the water rapidly up to 100° C. and no further?

Because all the heat communicated to the ice was utilized in performing the interior work referred to in the preceding paragraph and therefore could not at the same time increase the temperature of the ice (solid water); but the heat afterwards communicated to the water did not do any interior work but raised the temperature instead until the boiling point was reached. At the boiling point the water could no longer exist in a liquid state, because the tension of its vapor at that temperature is greater than the atmospheric pressure and the continued application of heat, therefore, resulted in the vaporization of the water, all the heat now communicated doing "interior work" again in overcoming cohesion (55).

313. Similar results follow the application of heat to other solids and liquids.

Any given solid always melts at the same temperature if the pressure be the same.

Any given liquid always boils at the same temperature, provided the pressure be the same.

Hence any given fusible solid has its own specific melting point (376); any given vaporizable liquid has its own specific boiling point (392); and any vaporizable solid, which does not melt before it vaporizes, always volatilizes at the same temperature.

But different substances generally have different melting points, different congealing points (382), and different boiling points.

314. Temperature.—The intensity of heat is called *temperature*. It is measured by the expansion it produces in the volumes of bodies (320).

The molecules of all matter are in continual motion, and all bodies have heat. Increased intensity of heat motion means a higher temperature, and slower molecular motion means a correspondingly lower temperature.

315. The old theory of heat regarded heat as "imponderable matter," or matter without weight.

But there can be no matter without weight, for matter is nothing else but that which is weighable.

It was thought that turning a solid into a liquid by the aid of heat was to add heat to the solid, the result of this union of two things being a liquid; and that by adding more heat to the liquid a gas was produced. It was further said

that the gas could be turned into a liquid again by taking away heat from it, and that liquids were turned into solids in the same way.

The strongest confirmation for this theory was the fact that when bodies are reduced in volume by pressure, heat is generated. It looked as if heat could be squeezed out of the matter.

But the "sensible" or "active" heat which makes its appearance when the volume of a body is diminished by pressure is pre-existing *energy* manifesting its presence by new phenomena.

316. *The Sun*, which is the source of all the energy of the life of plants and animals, and of nearly all the energy employed in mechanics, is also the greatest source of heat. It is the first source of most of the available heat of the globe. The total heat emitted by the sun is two thousand one hundred and twenty-nine million times that which reaches our earth. *The fixed stars* also send radiant heat to the earth. As our vast coal beds are formed from vegetable growths, they represent stored up potential energy derived from the sun.

Heat is also stored up in the interior of the earth.

317. *Friction, percussion* and *compression* produce heat.

Fire may be produced by rubbing two pieces of wood against each other; savages produce fire in that manner. The composition on the end of matches ignites by comparatively light friction. If you rub a piece of metal against a stone it gets hot. A piece of steel held against a rovolving dry grindstone not only gets hot, but sends incandescent particles of steel flying from it.

A piece of wrought iron may be hammered until red hot. A single blow explodes a mixture of potassium chlorate and sulphur, and the composition in a percussion cap.

A piece of tinder fastened to the end of the piston of a strong glass syringe may be ignited by suddenly driving the piston into the tube; this result is caused by the great amount of heat liberated when the air is compressed.

318. *Chemism* also produces heat.

Whenever any two kinds of matter react upon each other chemically (319), heat is evolved. The amount of heat thus liberated is constant for any given reaction. Electricity is also generated by chemical action, and heat may be also produced by electricity.

319. *Combustion* is chemical action, and is one of the main direct sources of heat available to man.

But heat is liberated in very large amounts, even by chemical reactions, which are not accompanied by flame or light, as when diluted sulphuric acid and water of ammonia are mixed, or when lime is slaked by pouring water upon it.

But the relations of heat to chemism will be referred to again further on (536).

CHAPTER XVI.

320. Temperature (314) is measured by instruments called thermometers. These are so constructed that the expansions and contractions caused by changes in the temperature can be easily seen and expressed.

The substances most used as indicators are mercury, alcohol, metal and air, all of which respond readily and sufficiently regularly to the changes in the velocity of heat vibration.

321. The mercurial thermometer, which is so universally employed, is constructed as follows :

It consists of a glass tube of extremely fine calibre—a capillary canal—expanded at its lower extremity into a bulb (fig. 83). The bulb and part of the tube are filled with pure mercury, after which the air is carefully expelled and the upper end of the tube closed. The instrument is then inserted into pounded ice, and the point at which the top of the mercury then stands is marked. The next step is to suspend the tube in the steam rising from pure boiling water in such a way that it is completely surrounded by it. This causes the mercury to rise in the tube until it reaches a certain point at which it stops and remains fixed. This point is also marked. The interval between these two points is now graduated into 100, 180, or 80 equal spaces (or intervals, called degrees) according to whether the *scale* is to be that of Celsius, Fahrenheit, or Réaumur.

The scale of degrees is, therefore, based upon the melting point and boiling point of water.

322. The Centigrade Thermometer. — The thermometer scale devised by Celsius (Fig. 85) is deservedly esteemed the most simple, rational, and worthy of universal adoption. It is called the *centigrade thermometer* because the interval between the melting and boiling points of water is divided into one hundred degrees (or equal spaces). The scientific simplicity
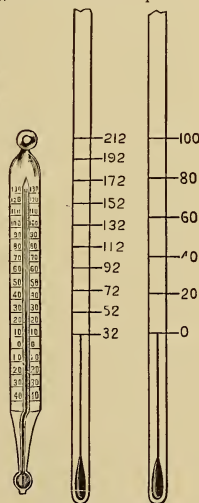
Figs. 83, 84, 85.

of this thermometer as compared with others has led to its almost universal employment in science.

Although Fahrenheit's thermometer (325) is the one in general use for ordinary purposes in the United States, the centigrade thermometer is used by our chemists and in the Pharmacopœia.

323. On the centigrade scale the freezing point (or, rather, the melting point) of water is denominated zero ($= 0°$), and the boiling point consequently $+ 100°$. The degrees above zero are the *positive* ($+$) degrees, and those below it, which are made of equal length on the scale, are called *negative* ($—$) degrees.

324. On *Reaumur's* scale the freezing point is also zero, or $0°$, but the boiling point is $+ 80°$. Thus four degrees R. are equal to five degrees C., and

C.° : 100 :: R.° : 80°.

In order, therefore, to convert any number of degrees R. to the corresponding number of degrees C., multiply by $\frac{5}{4}$; and to convert from C. to R., multiply by $\frac{4}{5}$.

325. Fahrenheit's thermometer (Fig. 84), which is almost exclusively used by the people of the United States and Great Britain, has the freezing point marked $+ 32°$, and the interval between this point and that at which water boils is divided into 180 equal spaces (instead of 100 as in the centigrade thermometer). Thus $+ 32°$ F. equals $+ 0°$ C., and $100°$ C. equals ($32 + 180 =$) $+ 212°$ F. Nine degrees on Fahrenheit's scale occupy the same distance, relatively, as five degrees on the centigrade scale.

But to convert F.° into C.° it will not answer to multiply the number of degrees F. by $\frac{5}{9}$ until after 32 has been deducted from the number, for C.°: 100 : : (F.°—32) : 180, or 9 C.= 5 (F—32); and in converting C.° into F.° the number of degrees C. must first be multiplied by $\frac{9}{5}$ and then 32 added to the product.

The rule, then, for reducing thermometric degrees from C. to F. is——

Multiply by $\frac{9}{5}$ and add 32.

and the rule for reducing Fahrenheit's degrees to Centigrade is——

Deduct 32 and multiply the remainder by $\frac{5}{9}$

326. Mercury thermometers are made to indicate temperatures from —30° F. to + 600° F. At very high temperatures, however, the scales are liable to vary from each other somewhat, for want of an unexceptionable natural

standard by which they may be corrected. When sealed at the top a good mercury thermometer can not be made to indicate temperatures above $+580°$ F., as the mercury may boil above that point. But the most accurate instrument indicates correctly only degrees between $-35°$ C. and a little over $+200°$ C.

327. As the freezing point of alcohol is much lower than the freezing point of mercury alcohol thermometers (or " spirit thermometers ") are used for measuring very low temperatures.

The alcohol in the tube is usually colored red so that the readings may be easier.

328. *Pyrometers* are metallic thermometers, or instruments by which temperature is measured by the linear expansion of bars of metals. They are of various forms, but their indications are very uncertain.

329. *Air thermometers* are very sensitive, and the most reliable thermometer known is Regnault's air thermometer; but it is too complicated to be described in such a book as this, and is used only for special scientific determinations and comparisons.

330. *Laboratory thermometers* used for measuring high temperatures of liquids, in chemical and pharmaceutical work, are constructed somewhat differently from those intended for ordinary purposes. They are long and slender, of exceedingly fine bore, and have very small bulbs (Fig. 86). The advantages gained by these conditions are that the divisions on their scales are larger and, therefore, more accurate, and the instrument readily attains the temperature of any liquid in which it is plunged, without materially affecting it. Small thermometers—slender tubes of small internal diameter—are, as a rule, more accurate than larger ones.

Fig. 86.

CHAPTER XVII.

331. Absolute Heat and Specific Heat.—It has been shown (321) that the arbitrary *degrees* of temperature indicated by all thermometers are based upon the constant temperatures of boiling water and melting ice under the pressure of one atmosphere.

But these degrees do not tell us how much heat a body contains.

Thus the zero point does not indicate absence of heat, nor does a temperature of 100° indicate that a body at that temperature contains 100 times as much heat as it contains when at 1°, nor that boiling water is twice as hot as water at 50°.

Bodies have been cooled to —220° F. without reaching the absolute zero (332).

332. Absolute Temperature.—Air and other gases expand uniformly with equal increments of temperature (364). Air thus expands to the extent of $\frac{1}{273}$ of its volume for every added degree according to the centigrade scale. Therefore air of $+273°$ C. occupies twice as much space as is occupied by the same amount (by weight) of air at 0° C. Below zero the volume of the air is diminished in the same ratio, so that if it be cooled to $-273°$ C. its volume must theoretically be reduced to nothing provided it remains in a gaseous state; but the air becomes a solid long before that temperature is reached, and it would then no longer obey the law of Charles (333).

It is assumed, however, from the foregoing, and for other more conclusive reasons, that at $-273°$ C. all bodies become entirely devoid of heat. That point is, therefore, called *absolute zero*, and temperature counted upward from absolute zero is called *absolute temperature*. On this scale all temperatures would be positive (323.)

333. The law of Charles is that the volume of a given mass (7) of gas at constant pressure is directly proportional to its absolute temperature.

334. The Specific heat of a body is the ratio of its capacity for heat as compared with that of an equal volume of water.

As water is the standard comparison the specific heat of water is of course 1, and the specific heats of the other bodies are expressed in water units, just as specific weights are also expressed in water units.

335. Thermal Units, or heat units.—The amount of heat necessary to raise the temperature of one kilogram of water one degree C. is called the unit of heat, or thermal unit.

It follows that the number of thermal units necessary to raise the temperature of any given body one degree expresses the specific heat of that body. (Heat units are also sometimes called *calories*.)

336. The temperatures of equal masses of different substances are not raised equally by equal amounts of heat.

If equal weights of mercury, alcohol and water are exposed to the same heat, the mercury will rise 30°, while the alcohol rises 2° and the water 1°. In other words, it requires 30 times as much heat to raise the temperature of water one degree as it takes to raise the temperature of the same quantity of mercury one degree ; and it takes twice as much heat to raise the temperature of a kilogram of water from 0° to 1° C. as is required to raise the temperature of a kilogram of alcohol from zero to 1° C.

337. But the specific heat of all solids and liquids, and of most of the gases, increases slightly with the temperature.

Thus water at 0° C. has the specific heat 1 ; water at 40° C., 1.0013 ; at 80°, 1.0035.

Liquids usually have a higher specific heat than solids and gases. The specific heat of water is almost double that of ice, and a little more than twice the specific heat of steam.

338. Water possesses a greater capacity for heat than any other substance except hydrogen.

It requires more heat to warm it, and gives out more heat in cooling through a given range of temperature. The same quantity of heat that raises the temperature of one kilogram of water from 0° C. to 100° C. heats one kilogram of iron from 0° to 800° or 900° C., or above red heat.

339. The heat lost in cooling is precisely the same amount as is required to raise the same body through the same number of degrees.

Therefore, when equal weights of different substances are heated to the same temperature and then placed on ice, the amount of ice melted will be in proportion to the number of thermal units they contain. If a given weight of

boiling water will melt one pound of ice, an equal weight of sulphur of 100° C. will melt $\frac{1}{6}$, iron $\frac{1}{9}$, and mercury $\frac{1}{30}$ of a pound of ice.

340. If one kilogram of water at 100° C. be mixed with the same quantity of water at 0° C., the temperature of the mixture will be $\frac{100°+0°}{2} = 50°$ C.

Thus the heat lost by the boiling water is precisely the same amount as that gained by the ice water. But this simple result does not follow when different substances are mixed.

341. The high specific heat of water explains why the vicinity of large bodies of water produces such a decided effect in moderating climate.

Lake Michigan makes the summers of Chicago cooler, and its winters warmer.

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CHAPTER XVIII.

DISTRIBUTION OF HEAT.

342. Distribution of Heat.—Heat may be conveyed from one body to another not only when they are in contact, but also when there is a distance between them. In the former case the heat is transmitted either by *conduction* or by *convection;* in the latter by *radiation.*

343. Conduction.—If a piece of metal be heated at one point, we may readily observe that the heat gradually spreads throughout the whole mass. The same transmission of heat takes place when two bodies of different temperatures are brought into intimate contact with each other; the temperature of the colder body increases, while that of the warmer decreases, until both have attained the same degree (382).

This is called the *conduction* of heat, and the heat motion is communicated from molecule to molecule.

344. The rapidity with which heat is *conducted* from mole-

cule to molecule varies in different substances; but the tendency to an equalization of temperature is universal. Any body having a higher temperature than surrounding bodies, will sooner or later impart to them some of its heat, until all have attained the same rate of molecular vibration.

345. The power of any body to conduct heat is generally proportional to its density. Metals and stones are *good conductors* of heat; they quickly become heated, and as quickly cooled, and are commonly designated as *cold bodies*. Porous substances, like wood, wool, cotton, are poor *conductors* of heat; they are less readily made *hot*, retain their temperature longer than the good conductors of heat, and are called *warm bodies*.

Liquids and gases are almost *non-conductors*. Feathers, fur, and wool owe their non-conducting properties largely to the air confined between their fibres and meshes.

346. The conducting power of a body may be judged of to some extent by the sense of touch. In cold weather stones and metals feel colder to the touch than glass, resin, wood, water or air, and in the summer the same stones and metals feel hotter than the other objects. Oil cloth on the floor is colder in winter and warmer in summer than a woolen carpet.

347. Cooking utensils, such as kettles, pans, etc., and the vessels used by pharmacists and chemists for heating liquids, are made of good conductors of heat, such as metals, as far as practicable. Earthen ware, porcelain and glass, only, are used for these purposes, because many substances attack metals and are themselves affected by contact with metals.

Silver has a very high thermal conductivity, and copper is also an excellent conductor; iron is far inferior to either.

348. Poor conductors are extremely valuable, both as a means of preventing the escape of heat, and to exclude heat.

Thus, if a vessel containing a hot liquid or vegetables put in boiling water, be covered and placed in a wooden box lined with felt, and the box tightly closed, the high temperature will be retained for many hours. Shrubs and plants are wrapped in straw to prevent the escape of their heat. Snow protects vegetation from the extreme cold of winter. Furnaces would be useless without the fire brick which, being made of non-conducting material, retains the heat. Clothing keeps the heat of our bodies in and keeps the cold of the air out. Animals in cold regions are protected by their fur and down.

349. Convection is the transmission of heat vibration by the motion of masses of molecules in currents.

Convection, therefore, occurs only in liquids and gases, in which currents are possible. It depends upon gravitation. Hot or warm liquids and gases are lighter or less dense than colder liquids or gases; and lighter fluids rise to the top while the denser fluids sink to the bottom. If, therefore, heat is applied under a kettleful of water, that portion of the water, which is first heated will rise to the surface, while other portions of water take its place, and currents are thus established in the liquid, which materially aid in diffusing the heat through the whole mass. A fire in a grate heats the air above it and the heated air rises through the chimney, while a new supply of air takes its place creating a *draft*.

350. In all cases where currents are thus established in fluids by the application of heat at the bottom of the liquid or gas, the currents are in opposite directions, the heated fluids rising upward while the cooler portions flow in downward currents.

The lower strata of air are warmed by the earth and then rise, the colder strata descending to take their place. Moreover, as the earth is not heated equally in all places, horizontal currents are established in opposite directions, which we call *winds*.

351. **Ventilation** is intimately connected with the convection of heat and the opposite currents established by it. Ventilation is the removal of vitiated air from rooms, shops and other, confined spaces, and the supplying of fresh air to take its place the object being to maintain the atmosphere in a state of purity.

In apartments occupied by men or by animals the air becomes vitiated by respiration, the oxygen of the air being consumed, carbon dioxide taking its place. An adult man inhales about fourteen cubic feet of air per hour; but it is not enough that the amount of air in the apartment be sufficient for the inhalation of fourteen cubic feet per hour. The air inhaled must be *pure* at any and all times, and this requires a constant supply of fresh air and a constant escape of the vitiated air.

The combustion of oil or gas for illumination also consumes oxygen, and thus vitiates the atmosphere of a room.

When a window is opened to produce a change of air, it should be opened *at the top*, because the cold, fresh air entering near the ceiling diffuses through the whole room, while the foul air being warm, escapes.

The air in a room is warmest at the ceiling. Hence, in a drug store, substances which are liable to be injured by the higher temperature in the upper strata of the atmosphere of the room should not be kept on the top shelves.

352. **Radiation of heat.**—The heat which is diffused through space from the sun reaches the earth by *radiation*.

353. In order to be able to explain or understand how heat and light can be received by us from the sun, it is necessary to assume that the space which separates the terrestrial atmosphere from the sun can not be empty, for motion can not be communicated by nothing or through empty space. It is, therefore, assumed that there is a medium, which has received the name of **ether,** capable of communicating motion, and occupying all of the otherwise unoccupied space in the universe. Ether is accordingly supposed to penetrate between all molecules of matter. Ether is not matter; it can not be weighed nor measured. It can not be seen, heard, felt, tasted nor smelled. But its existence is assumed because the phenomena occurring in nature can not be accounted for on any other supposition, while they are explainable on the hypothesis that an ethereal medium exists which is capable of transmitting motion. These phenomena occur in just such a manner as they must occur if all space were filled with such a medium.

354. Sound, light and heat are transmitted through the medium of ether, and are, therefore, referred to as forms of *radiant energy*. They are communicated by a wave-like, vibratory motion, and this theory of wave-action is called the *undulatory theory*. All the phenomena of light and of radiant heat show a remarkable analogy.

355. Heat radiates in straight lines in all directions, and the intensity of radiant heat is inversely as the square of the distance from its source and proportional to the temperature of that source.

356. Different bodies vary greatly in the power of emitting radiant heat. Lamp black has the highest radiating power known, and polished metals are the poorest radiators of heat. A bright silver tea-pot filled with hot liquid retains its temperature longer than one of earthenware.

Steam pipes for heating buildings should be kept bright until they reach the rooms where the heat is to be diffused; there they should be coated with lamp black to increase their radiating power.

357. Heat is *reflected* by all substances which are good reflectors of light. Thermal rays are also *refracted* like rays of light, but the thermal rays are of different refrangibility and wave length (421).

Transparent bodies generally transmit heat as well as light from the sun, but they do not transmit equally the heat rays from artificial sources.

The heat from the sun warms the room through the window-glass, but the same thickness of glass intercepts the heat from the fire-place.

Different substances *transmit* heat unequally, and *absorb* heat unequally. Heat rays which are absorbed increase the temperature of the bodies which absorb them; rays which are transmitted or reflected do not warm them.

CHAPTER XIX.

THE EXPANSION OF BODIES BY HEAT.

358. The first and universal effect of heat upon most bodies is to increase their volume (309).

This expansion of a body by heat is the result of a widening of the distances between the molecules of the body. Heat motion increases the inter-molecular spaces, and thus overcomes cohesion.

359. Numerous easy experiments might be described here to prove that heat expands matter; but you can doubtless invent some yourself, and I will, therefore, only refer to a few familiar examples.

The mercury or alcohol in the thermometer (320) expands with an increase of temperature, and contracts with a reduction of it.

The rails of a railroad are of necessity laid in such a manner that their ends are not in actual contact even in hot summer weather; if they were laid without any space between their ends they would expand under the influence of the heat from the sun so as to bend out of shape. In cold weather there is considerable space between the ends of the rails.

A metal ball or cylinder which, when cold, passes through but nearly fills a metal ring will not pass through if heated.

If you fill a tin cup to the brim with cold water and set it on a hot stove the water will run over when it becomes warm.

If a glass stopper has been inserted into the neck of a bottle so tightly that it can not be removed in the usual way, you can loosen it by *warming* the neck of the bottle, for as the neck of the bottle expands the stopper will, of course, no longer fill it so tightly.

[In doing this remember that only the neck of the bottle is to be expanded and not the stopper, for if you heat the neck so long that the heat is transmitted to the stopper, too, both will expand. Moreover, take care that the heat be applied cautiously so that the glass may not break (365). The neck of the bottle may be heated by friction (317), which is easily applied by pulling back and forth a cord tightly wound around it.

360. Force of Expansion and Contraction.—Water expands for each degree F. with a force equal to ninety pounds to the square inch; *i. e.*, it would require that amount of force to resist its expansion when its temperature is increased one degree.

To compress boiling water back to its volume at the freezing point would require a pressure of one thousand atmospheres, or a layer of mercury almost half a mile thick.

361. The expansion of solids and liquids by heat is unequal.

Gases, however, expand equally and uniformly (364); under equal pressure their volumes increase in the same ratio with equal increments of temperature, and at equal temperature their volumes are inversely as the pressure which they sustain (Boyle, Mariotte and Charles).

Gases, when their temperature is raised, expand more than solids and liquids.

362. *Linear expansion* (or linear dilatation) is expansion in one direction only, as when a rod or an iron rail is lengthened by an increase of temperature.

363. *Cubical expansion* (or cubical dilatation) is expansion of volume. Solids, liquids and gases are all subject to cubical expansion and contraction as their temperature increases or decreases.

364. Co-efficients of Expansion.—By "co-efficient of expansion" is meant the number which expresses the measure of the expansion of a body when its temperature is raised one degree. The ratio of expansion for gaseous bodies is 0.003663 (or $\frac{1}{273}$) of their bulk for each degree C., or 0.002037 (or $\frac{1}{490.9}$) for each degree F., above the freezing point of water. This means that the bulk of a gas is increased by 0.003663 (or $\frac{1}{273}$)

when its temperature is increased one degree by the centigrade thermometer, and by 0.002037 (or $\frac{1}{490.9}$) when it is raised one degree by Fahrenheit's scale.

In the case of solids and liquids the ratio of expansion increases as the temperature rises.

365. *Unequal expansion* by heat often results in the fracture of brittle *solids*; that danger is greater the thicker the solid is, and greatest when the thickness is unequal.

Cast iron and glass, when suddenly heated, are liable to crack, because the side to which the heat is applied expands more rapidly than the other side. Sudden cooling has the same effect by causing unequal contraction. Thick vessels of glass, porcelain, wedgewood ware, etc., like graduates, mortars and bottles, and especially vessels of unequal thickness, are frequently cracked by carelessly heating or cooling them suddenly. Do not pour hot liquids in cold glass or eathenware vessels nor cold water in the same vessels when hot, and do not put a hot dish on a cold surface nor a cold one on a hot surface.

366. Expansion of Water.—Water forms the only exception to the rule that bodies expand whenever their temperature is increased, and contract whenever the temperature is lowered, for the *maximum density* of water is attained at 4° C. (39.2° F.), and it expands both below and above that temperature.

If you fill two strong bottles completely with ice water, cork them tightly and tie the corks securely with wire, and then let one of them be exposed to such cold that the water will freeze, and warm the other, both will burst, because the water in both bottles will expand.

367. Were it for the fact that ice is lighter than the water upon which it is formed, all those portions of the globe where the temperature in the winter season falls below the freezing point of water would be uninhabitable; for, if the solid water (ice) were heavier than liquid water, the ice would sink as fast as it is formed, and all the rest of the water would be gradually frozen to ice, until all the lakes and rivers were frozen solid from bottom to surface. The heat of summer would then be insufficient to melt the ice.

But, as water is heavier at 4° C. than when it has any other temperature, the water at the surface of the lakes and rivers, as soon as it is cooled down to + 4° C., sinks to the bottom, and the warmer water rises to take its place and to be in turn cooled to the same temperature, until the entire body of water has a temperature of + 4° C. before any ice is formed, after which the ice formed on the surface, being lighter than the water below, remains floating.

At the moment of freezing, water suddenly increases in volume about ten per cent.

368. At its maximum density (+ 4° C. = 39°.2 F.), water is 773 times as heavy (or dense) as air of 0° C.; but water at 15° C. is 819 times as heavy as air of the same temperature.

Thus water and air expand very unequally with the increase of their temperatures.

369. Water freezes at 0° C. (32° F.), or under certain conditions several degrees below that temperature.

If you boil some water (to expel the air from it), put it in a bucket or other vessel and let it stand perfectly at rest, with a thermometer hanging down into it, allowing the water to cool slowly, the water may remain liquid until the thermometer indicates —3° or —4° C. But if you then suddenly stir the water around with the thermometer it will freeze at once, and its temperature will then at the same time rise to 0°, because the latent heat which the water absorbed in its expansion *below 0°* is liberated as it contracts to form ice at 0°.

370. The expansion which takes place when water freezes to ice *at zero* (C.), bursts porous stones, and great rocks may be split by boring holes in them, filling these with water, plugging the opening tightly and allowing the water to freeze.

371. Ice contracts more than any other solid upon being cooled. Under strong pressure ice may be rendered liquid even at —18° C.

372. The melting point of ice is uniformly 0° C. under the ordinary atmospheric pressure. In thus passing from the solid to the liquid state, water takes up an amount of heat sufficient to raise the temperature of a like quantity of water from 0° C. to 79° C.

373. When heated above 4° C. water continues to expand until it reaches the boiling point, which is at 100° C. (212° F.) at the ordinary atmospheric pressure. The boiling point is lower under less pressure, and higher under greater pressure.

Under the pressure of two atmospheres the boiling point of water is at +121° C., and under three atmospheres at +134° C. But on high mountains, where the barometric (or atmospheric) pressure is less (285), the boiling point of water is correspondingly lower, so that the altitudes of mountains may be determined by the temperature at which water boils on their summits.

374. Water evaporates (390) at all temperatures.

Even ice gives off vapor.

This tendency of water to form vapor is its *tension* (279) which increases as the temperature increases, and can be accurately measured.

CHAPTER XX.

375. As the several states of aggregation of matter (68) depend greatly upon their temperature (314) we may look upon solids as matter in a frozen condition, liquids as melted matter, and gases as vaporized matter. Different kinds of matter congeal or freeze to a solid mass at different temperatures ; they fuse or melt at different temperatures ; and they boil or vaporize at different temperatures, according to their kind.

Hydrogen does not exist at ordinary temperatures except in the gaseous state ; indeed it requires great cold and pressure to condense it to a liquid, and that liquid boils at the low temperature of —210° C. under a pressure equal to 190 atmospheres, or at —140° C. under 650 atmospheres.

Alcohol is a liquid at ordinary temperatures, and does not freeze solid until at —130° C.; but it boils at about 78° C. (172°.4 F.).

Oil of Theobroma or "Cacao Butter" is at the ordinary temperature a solid ; it melts to a liquid by the warmth of your hand, and is frozen solid again a little below that temperature.

But gold is frozen solid at a temperature exceeding 1,000 degrees above zero, according to the centigrade thermometer (322), or over 1,800 degrees by Fahrenheit's scale.

376. Many **solids** can be changed into liquids by heat. Their liquefaction by heat is called *fusion;* solids which melt or fuse when heated are said to be *fusible*, and the particular degree of temperature (314) at which a solid undergoes fusion is called its *melting-point* or *fusing-point*.

Metals, resins, fats, and many other solids are fusible.

But there are also many *infusible* solids, as starch, gums, wood, carbon, clay, etc.

Ores which are either infusible, or melt only with extreme difficulty at extremely high temperatures, are called *refractory ores*.

377. Some solids when subjected to high heat "volatilize without fusion," or pass into a state of vapor without melting.

Arsenous oxide, benzoic acid, gallic acid, calomel, and many other solid substances volatilize and *sublime* (405) without fusing.

Vaporizable solids are said to be *volatile*.

378. Softening by heat without fusion.—Many substances soften materially much below their melting point.

Ointments, cerates and plasters, and the fatty substances and resins from which they are made, generally have that property.

Other substances which do not fuse at all are, nevertheless, rendered soft, plastic, or pasty when heated, becoming hard again on cooling, as is the case with many dry solid extracts.

379. There are many solids which are both fusible and volatilizable; but there are other solids, which, although fusible, can not be converted into vapor.

380. Fixed substances are those which can not, by ordinary means, be made to assume the gaseous state.

If a sufficiently intense heat could be applied, it is probable that all substances could be converted into vapor; but bodies which are not volatilized at the high temperatures which can be produced by the means at our command, are said to be fixed. *Fixed alkalies* are the non-volatile hydrates of potassium and sodium, but ammonia is a volatile alkali. Most mineral substances are fixed, as the metals, etc.

381. All liquids and gases can be turned into solids by cold or by pressure, or by both; but not all liquids can be converted into vapor; nor can all solids be turned into fluids.

382 Bodies in a state of fusion reassume the solid state after the application of heat has been discontinued and the usual equalization of temperature has taken place (343).

Certain substances, which solidify at high temperatures, liberate so much heat at the moment of solidification (or congelation) that they become glowing throughout their mass.

The temperature at which liquids solidify is called their *congealing point* or *freezing point*. Theoretically, this point is nearly identical with, or but slightly below the degree at which the solid became liquid; but it frequently happens that liquids retain their liquid state below that point, in which case they give off their latent heat all at once, when solidification at last takes place (369).

383. *Expansion at the Moment of Solidification* —That water expands with great force at the point of freezing we have already noted (370). Water pipes burst in cold weather if the water in them is allowed to freeze. But some metals, too, expand when they solidify, as cast iron, tin, zinc, bismuth, antimony and some of their alloys. Such metals and alloys are used to make casts because they fill the molds so perfectly by their expansion that the casts become very sharp and perfect.

Most substances, however, contract in the act of solidifying; thus coins of silver, gold and copper can not be cast in molds, but must be stamped.

384. A curious phenomenon connected with this subject is the fact that mixtures of solids produced by fusion, such as alloys of metals and fatty mixtures, frequently have lower fusing points than either of the constituents of the mixture. Thus Rose's alloy, which consists of 4 parts of bismuth, 1 of lead, and 1 of tin, fuses at 94° C. (201° F.). A mixture of equal parts of potassium carbonate and sodium carbonate melts at a lower temperature than either salt separately.

385. That solids absorb heat (and render it latent) in passing into the liquid state is well illustrated in the solution of solids which take up so large an amount of heat as to greatly lower the temperature of the solvent.

Whenever a solid is dissolved in any liquid, the solid must take up latent heat in passing into the liquid state, but some solids take up more heat than others.

You may easily learn this by dissolving readily soluble salts in just enough water to accomplish their solution, and best by dissolving more than one salt in the same water; provided, of course, the salts used are such as do not decompose each other. Thus if you dissolve equal parts of ammonium chloride and potassium nitrate in barely sufficient water, you will observe that the temperature of the liquid falls rapidly, and the vessel as well as the solution becomes very cold. That is because the salts could not dissolve or become liquid without taking up heat, and they took this heat from the surrounding bodies—from the water in which they were dissolved, and then from the vessel in which the solution was performed, and from the contiguous air, and when you grasped the vessel in your hand heat was abstracted from your hand, producing the sensation of cold.

386. *Freezing mixtures* are made on this principle (385). Some mixtures of readily soluble salts with twice their weight of water depress the temperature about 20 degrees centigrade. A mixture of three parts crystallized calcium chloride with two parts of snow will cause mercury to freeze. The freezing mixture used in ice cream freezers consists of about two parts of snow and one part of common salt: this will produce a temperature of about —20° C. (—4° F.). Another effective freezing mixture consists of five parts hydrochloric acid and eight parts crystallized sodium sulphate.

387. There are some substances which change from the solid to the liquid state or *vice versa* at common room-temperatures, as glacial acetic acid, volatile oil of anise, oil of rose, etc. They are frozen solid in a cold room, and melt into liquids again in a warm room.

388. Numerous liquids are vaporizable by heat, and if the temperature at which they *vaporize* is not comparatively high the liquids are said to be *volatile*.

Water, alcohol, ether, benzin, gasolin, are vaporizable, and all of them, except water, are *volatile liquids*.

389. Substances which are liquid only under pressure vaporize at once upon the removal of the pressure.

Ammonia, carbonic oxide, nitrous oxide, and several other gases are now compressed into a liquid state in cylinders.

390. Evaporation.—The slow conversion of bodies into vapor may take place at any temperature. Thus, we have seen (374) that water vapor will pass off even from ice.

Volatile solids evaporate at ordinary temperatures, as, for instance, camphor, iodine and chloral. Water evaporates constantly.

Evaporation under the ordinary conditions of temperature and pressure is sometimes called *spontaneous evaporation*.

391. The Rate of Evaporation increases with the temperature because heat increases the tension of vapors. It also varies inversely with the pressure to which the evaporating liquid is subject, because greater pressure involves greater resistance to the vapor tension. Evaporation is far more rapid in a vacuum than in air.

The rate of evaporation also depends upon the amount of vapor of the same kind already contained in the air into which the evaporation is going on. It is greatest when the air is free from vapor, and ceases when the air becomes saturated. Hence, if the air be changed frequently or continually, so that it can not become charged with too great a proportion of vapor, the evaporation will proceed more rapidly than if the air is stationary, and thus becomes saturated, or nearly so.

In a breeze the evaporation of water from the surface of the earth is much more rapid than when the air is still.

As evaporation can take place only at the surface of a liquid, the rate of evaporation also depends directly upon the extent of surface exposed.

392. The temperature beyond which a liquid can not continue in a liquid condition without increased pressure is its **boiling point.**

In other words, the boiling point of a liquid is the temperature at which it *boils* or becomes rapidly converted into vapor. A comparatively rapid

conversion of a solid or liquid into vapor at the boiling point is called *vaporization*.

Boiling is often called *ebullition*.

393. The boiling point of a liquid depends upon the nature of the liquid and upon the pressure of the superimposed air.

Carbon dioxide boils at —42°.44 C. (—108°.4 F); stronger ether at 37° C. (98°.6 F.); alcohol at 78° C. (172°.4 F.); water at 100° C. (212° F.); mercury at 350° C. (662° F.); zinc at 1040° C. (1904° F.).

Salts and other substances held in solution in the liquids generally raise the boiling points of the latter. Liquids of great density usually have higher boiling points than lighter liquids, but there are many notable exceptions. If you compare the densities and boiling points of alcohol and ether, you will find that the rule holds good; but if you compare alcohol and chloroform, you will observe that although chloroform is more than one and three-fourths times as heavy as alcohol, it boils at about 61° C., while alcohol does not boil until 78° C.

394. Saturated solutions of salts are often used to fix the degree of temperature applied to vessels and their contents in laboratory operations, for saturated solutions have fixed boiling points.

Thus a saturated solution of common salt boils at 108°.4 C. (227° F.); one of potassium nitrate at 115°.9 C. (240° F.); of calcium chloride at 179°.5 C. (354° F.).

But the water vapor formed when these solutions boil does not retain the high temperature of their boiling points.

395. *Boiling points vary with the pressure*.—The vapor in its formation and continued existence must overcome all pressure from without which tends to condense it. As already stated, the boiling point of a liquid is that temperature at which the tension of its vapor is greater than the pressure which it sustains.

The measure of the atmospheric pressure must, therefore, be considered in the determination and expression of boiling points. When we speak of fixed boiling points, then, the boiling points under a pressure of one atmosphere (284) are the boiling points referred to.

At the level of the sea, water boils at 100° C. (212° F.); on Mount Blanc it boils at 84° C. (183°.2 F.); and in a "Papin's digester," which is a strong, hermetically closed metallic vessel, the temperature of water may be raised to a very high degree without causing it to boil. In a steam boiler the water may attain a temperature of over 200° C.

396. The vapor formed from water boiling under normal pressure is of the same temperature as the boiling water, or 100° C. (212° F.). Under pressure, as when the steam is confined in boilers, pipes, coils, steam jackets, etc., the temperature of the steam increases with the pressure.

But steam may be heated after it has been produced; it may be passed through pipes into a furnace and there heated to a very high temperature. It is then called *superheated steam*, or dry steam.

397. In a vacuum water boils at the ordinary temperatures.

If a vessel of water of about 30° C. be placed in a glass bell and the bell then exhausted by means of an air pump, the liquid begins to boil after a few strokes; but the ebullition soon ceases on account of the pressure produced by the vapor which takes the place of the abstracted air. As soon as this vapor is pumped out, ebullition again sets in.

If a long-necked flask of uniformly thin glass be half filled with water, the water boiled a few minutes so that the air might be expelled and replaced by water vapor, and the flask then removed from the source of heat, and promptly and tightly corked, the ebullition at once subsides; but if this flask be now immersed in cold water up to the neck, the contents will again boil briskly. This is because the vapor contained in the upper part of the flask is condensed by the cold so that a vacuum is produced, thus removing the pressure and greatly lowering the boiling point.

398. When a mixture of several liquids of different boiling points is heated, it boils at a temperature somewhat above the boiling point of the most volatile constituent of the mixture.

399. You have read that whenever a liquid passes into the gaseous state it takes up latent heat.

This latent heat is called "the latent heat of vapors."

It requires $5\frac{1}{3}$ times as much time to convert a given amount of water into vapor as it takes to raise that water from 0.°C. to 100° C., the heat applied being the same. Thus the latent heat of steam is $5\frac{1}{3} \times 100 =$ about 537° C. (967′ F.).

The same amount of heat that is necessary to evaporate one Gram of water is sufficient to raise the temperature of one Gram of water 537 degrees (centigrade), or to raise the temperature of 537 Grams of water one degree.

The latent heat of alcohol vapor is about 190°.6 C. (374°.9 F.). That of ether vapor is about 72°.5 C, (162°.8 F.).

400. Cold from Evaporation.—The heat which is neces-

sary to convert a liquid into a vapor is taken from the surround-
ing bodies.

This fact is not noticed in vaporization by boiling because heat is con-
stantly applied to the vessel containing the boiling liquid. But when evap-
oration goes on at comparatively low temperatures the reduction of tempera-
ture may be readily observed in the liquid itself, the vessel containing it, and
the surrounding air.

A rain shower cools the atmosphere because the water evaporates, and in
doing so takes up heat from the air.

If you put a small quantity of "stronger ether" in a watch crystal and
let it evaporate at the temperature of the room, the ether will take up so much
heat in its rapid evaporation that a drop of water on the other (convex) side of
the watch crystal will be frozen to ice.

When ether or alcohol evaporates from your hand a sensation of cold is
produced.

401. When vapors are deprived of their latent heat they are
immediately condensed, or return to the liquid state. Vapor
can not pass into the liquid state without liberating heat.

Steam heating is based upon this fact. The latent heat of steam,
together with most of its sensible heat, is available for heating purposes, as it
must give off that heat in returning to the common temperature.

Water is often heated to the boiling point in wooden tanks and in other
vessels by forcing steam into it.

402. Equal volumes of different liquids do not produce equal
volumes of vapor.

The expansion of water in passing into the state of vapor is greater than
that of any other liquids. The value of steam as a source of mechanical
power depends upon its expansive force. One cubic inch of water forms
nearly one cubic foot of water vapor or steam.

403. **Distillation** consists in vaporizing liquids in suitable
vessels, called *stills*, connected with *condensers* and *receivers* in
such a manner that the vapor can be reconverted into the liquid
state and thus collected, the object of the process being to sep-
arate volatile liquids from less volatile or fixed substances.

404. **Gases** can be *condensed* into liquids, or even into the
solid state, by cold, or pressure, or both.

It was until 1878 supposed that air, oxygen, hydrogen and nitrogen were
incompressible, incoercible, or permanent gases, *i e.*, that these gases could
not be condensed into either the liquid or the solid state. But all gases have
now been liquefied and solidified.

405. Sublimation is the vaporization of solids and the condensation of the vapor back to the solid state.

406. Distillation and sublimation are applied to the purification of substances resulting in the separation of volatile from non-volatile matters.

CHAPTER XXI.

TEMPERATURE AND HUMIDITY OF THE AIR.

407. *Saturation of air with vapor.*—The air is said to be *saturated* with vapor when it contains as much of it as it can hold. The quantity it can hold varies with the temperature, and with the kind of vapor.

The atmosphere is said to be *dry* when it contains a relatively small quantity of moisture, and *moist* or damp when it contains a greater quantity. But the sensation of dryness or humidity does not correspond with the relative percentage of moisture, for the air feels dry whenever it is capable of absorbing much more moisture than it contains, and moist whenever it approaches the *dew point*, which depends greatly upon temperature. A warm air which feels dry may contain much more moisture than a cold air that feels moist.

At 0° C. the air can take up $\frac{1}{316}$ part of its weight of water vapor; but for every increase of 11° C. its capacity for moisture is nearly doubled, so that at about 11° C. (52° F.) it may contain $\frac{1}{118}$ of its weight (or twice as much as at the freezing point), and at 22.22 or (72° F.) it can absorb $\frac{1}{59}$ (or three times as much as at zero C.).

408. The Dew Point.—If air that is saturated with moisture is cooled it can, of course, not retain all of that moisture; a portion of it must, therefore, be condensed (404) and deposited as dew, and the temperature just below the saturation point, or that temperature at which the moisture contained in the air can not all remain in a state of vapor absorbed by the air, is call the *dew point*. Whenever the air is nearly saturated with moisture the dew point will therefore be only a little below the temperature of the atmosphere, and a slight fall of temperature will cause dew to be formed, for it contains more moisture than it would contain if saturated at the temperature of the dew point. The

dew point is, therefore, lower when the air contains less moisture, and higher when its humidity is greater.

A vessel containing ice water will receive a deposit of dew upon the outside, which disappears again as soon as the vessel and its contents reach the dew point, which may be ascertained by a thermometer placed in the water.

The relative humidity of air is its degree of approach to saturation.

409. Clouds, fog, dew, rain, frost, snow and hail are the results of the condensation of atmospheric moisture into liquid and solid water.

When a mass of warm, moist air strikes a colder mass of air, a portion of the water vapor contained in the warmer air is condensed to *clouds* of little bubbles of water filled with air; when these gather and collapse, *rain* comes. *Fogs* are only clouds formed near the surface of the earth. Condensed below the freezing point, it becomes *white frost*. *Dew* is deposited upon objects which are cooled after sundown.

410. The temperature of the air is highest at the surface of the earth and decreases as the height of the atmosphere increases. Above a certain altitude, therefore, the air is so cold that perpetual snow and ice cover the mountain tops. But the altitude at which snow and ice never melt varies according to latitude and depends, further, somewhat upon other conditions. The altitude of perpetual snow and ice is fifteen times as great at the equator, as it is in a latitude of seventy-five degrees.

411. The temperature and moisture of the air have a direct influence upon health. Thus *cold and moist* weather is accompanied with a high death-rate from rheumatism, heart diseases, diphtheria and measles; *cold* weather, with a high death-rate from bronchitis, pneumonia and other diseases of the respiratory organs; *cold and dry* weather is attended with suicide and small-pox; *hot* weather brings with it a high death-rate from bowel complaints; and *warm, moist* weather exhibits greater mortality from scarlet and typhoid fevers.

CHAPTER XXII.

LIGHT.

412. **Light** is that mode of motion which affects the optic nerve, or excites in us the sensation of vision.

[Physically light is practically identical with radiant heat (314), the difference being merely that of wave length.]

413. The sources of light are: 1, mechanical action; 2, chemical action; 3, electricity; 4, phosphorescence; and 5, the heavenly bodies.

Bodies that emit light by their own vibrations, as the sun, or the flame of a burning substance, are called *luminous* bodies. But trees, rocks, and other bodies which merely diffuse light received by them from other bodies are *non-luminous* or illuminated bodies; they do not originate light.

414. *Transparent* substances allow light to pass through their bodies so that objects can be seen through them.

Water, air, glass, diamond; clean, clear crystals of sodium carbonate, Rochelle salt, copper sulphate, ferrous sulphate, lead acetate, zinc sulphate, borax, alum, iron alum, etc., are transparent.

415. *Translucent* bodies transmit light, but so imperfectly that objects on the opposite side can not be clearly seen through them.

Ground glass, horn, waxed paper, a sheet of gelatin, shellac, etc., are translucent.

416. *Opaque* bodies do not transmit light. By far the greater number of material objects are opaque.

They cut off the light so that other objects can not be seen through them at all.

417. *Luminous rays.*—Light *radiates* in all directions from every luminous point, and a single line of light is called a *ray*.

418. *Incandescence.*—Any solid heated to nearly 1,000° F., unless destroyed by such intense heat, emits, at that and higher temperatures, a dull red light, and is then said to be incandescent.

The light of incandescent bodies varies with the degree of heat, being dull red, bright red, blue, orange, or white as the temperature rises; the light increasing in brilliancy with the intensity of the heat.

419. *Phosphorescence* is a pale light, emitted in the dark, without any heat, as the light flashing from fire-flies, the greenish light sometimes seen in the wake of a ship at sea, or that exhibited by rotten wood, etc.

420. *White Light* is composed of seven colors. These seven

colors are red, orange, yellow, green, blue, indigo and violet—
the colors of the rainbow.

If a beam of light admitted through a vertical slit be made
to pass through a prism so placed that its edges are parallel
with the sides of the slit, and the beam caught upon a screen,
a band of the seven colors above named will appear on the
screen.   This band of the seven *prismatic colors* is called the *solar
spectrum*, the white light being decomposed into its seven constit-
uents in its passage through the prism.

421. *Refraction.*—When light passes obliquely into a medium
of different density, the rays are deviated from their original
direction.

This tendency of the luminous rays to be refracted or bent
in passing obliquely from one transparent medium into another
is called *refrangibility*.

The different color rays are not susceptible of refraction in the same degree;
the red ray is the least refrangible or is less bent than the others, while the
violet ray is the most refrangible.

It is this unequal refrangibility that produces the *spectrum* or band of
colors (420).

422. *Simple* or *primary colors.*—The seven prismatic colors can
not be decomposed or made to undergo any change of color, and
are, therefore, called the simple or *primary colors*.   Recombined
the primary colors produce white light.

423. *Complementary colors* are any two colors which will pro-
duce white when combined.   Red and green rays will produce
white light and are, therefore, complementary; blue and orange,
violet and yellowish-green, and indigo and orange-yellow are
also complementary colors.

424. *Color* is produced by the light *reflected* by the various
bodies.   A body which absorbs all of the colors of the rainbow,
reflecting none, appears *black;* one that reflects all the color rays,
absorbing none, appears *white;* all other bodies appear to have
the colors which they, respectively, reflect.   A red substance
seems red because it reflects only red rays of light, absorbing all
the other rays.

425. *Fluorescence.*—Some substances have the power of chang-ing their refrangibility of rays of light. The result of this is a change of color apparent upon the surface of these bodies, a bluish, greenish, or even reddish glimmer being diffused by them.

Fluor-spar, an acid solution of sulphate of quinine, tincture of turmeric, the fluid extracts of gelsemium and stramonium seed, and many other organic substances exhibit fluorescence. The glucoside æsculin contained in horse-chestnut bark has this property in a marked degree, one grain being sufficient to impart a distinct fluorescence to over twenty gallons of water.

426. Rays of light have three properties ; they are: 1, lumi-nous; 2, heating; and 3, producing chemical action.

The *luminous intensity* is greatest in the yellow, and least in the violet rays.

The *intensity of heat* is least in the violet and increases to (and beyond) the red. The spectrum contains invisible dark rays of heat, which are less refrangible than the red rays.

Light has a marked influence upon chemism.

427. The chemical action of light is necessary to the healthy growth of plants. Many plants do not thrive at all in the shade. For the elaboration of their food plants need the light as well as the heat of the sun's rays, and those rays of light which favor chemical reaction are of vital importance.

The bleaching power of light depends upon its chemical effect.

That light has very great power in this direction is shown by many of the familiar changes occurring in medicinal chemicals, as the darkening of yellow oxide of mercury, white precipitate, pyrophosphate of iron, etc., on exposure to light. Photography is based upon the decomposition of silver compounds by light. Hydrogen and chlorine combine very slowly in diffused light, but with explosive violence in direct sun-light.

428. But the chemical effect of the different rays is not equal. It is hardly perceptible in the red and yellow rays, but increases gradually toward the opposite end of the solar spectrum, becomes decided in the blue, and reaches its maximum intensity in and beyond the violet. Thus the chemical effect of the rays increases with their refrangibility, and the spectrum contains rays beyond the violet which are more refrangible than the violet rays, but not visible.

429. The chemical effect of light renders it necessary to pro-tect medicinal substances from its action.

Containers of colorless flint glass are, therefore, not suitable for holding substances affected by light ; blue or violet glass bottles, instead of affording

protection, hasten the decompositions or changes produced by light, as they transmit the chemical rays freely, while red, yellow, or amber-colored glass affords good protection by excluding the chemical (or "actinic") rays.

The damaging effects of direct sun-light upon medicines are more far-reaching than is commonly supposed.

CHAPTER XXIII.

ELECTRICITY.

430. **Electricity** can not be defined since it is not known what it is. It manifests itself by peculiar and striking phenomena of attraction and repulsion and in various other ways.

Electricity may be converted into all other forms of energy, and all other forms of energy can be converted into electricity (66).

431. Examples of the wonderful effects of electricity are seen in the lightning, the telegraph, electric lighting, the compass, magnets, electric motors, the telephone, etc.

432. There are two principal sources of electricity—friction and chemism.

Electricity developed by friction is called *frictional electricity*, or *static electricity*. It is also sometimes called "Franklinism."

Electricity developed by chemism is called *galvanic electricity*, or *voltaic electricity*, or dynamic electricity.

433. **Magnetism** is a manifestation of the electric force. The power of the *lode-stone* to attract iron is magnetism.

Lode-stone is an iron ore called "magnetic oxide of iron," and is a *natural magnet*.

Artificial magnets may be made by means of dynamic electricity.

434. While electric force developed by different means may exhibit differences as to some property, yet these differences are only differences as to degree and not as to kind. All the different forms of electricity are identical, each having all the properties of any other.

435. It has already been stated (430) that electricity exhibits striking phenomena of attraction and repulsion. This is because electricity has two opposite states, one called *positive electricity* and the other *negative electricity*.

Both kinds of electricity are always simultaneously produced.

If a lode-stone is rolled about in iron filings the iron will adhere to it, especially at the two opposite ends, which are called the *poles* of the magnet ; each pole attracts iron or any other magnetic substance ; but two magnets brought end to end will not attract each other regardless of *which ends* are thus brought together, for each end of the first magnet will attract but one end of the second magnet and will repel the other end.

436. An artificial magnet, or a steel needle which has been magnetized, poised at the center so that it will swing freely, is a *compass*. One of its ends always points toward the north and is called the north pole ; the opposite end is called the south pole. The north pole of one magnet attracts the south pole of the other, but if the north poles of two magnets are brought together repulsion takes place instead of attraction. Thus *opposite poles attract while like poles repel each other*.

Electricity is, therefore called a *polar force*.

437. Induction.—A piece of soft iron, or a piece of steel, may be magnetized by being brought near one of the poles of a magnet. The soft iron will become a *temporary magnet*, with its two poles, capable of attracting iron ; but it will soon lose its magnetic power. A rod of steel, on the other hand, treated in the same manner, becomes a *permanent magnet*.

This power of any magnet to develop magnetism in a piece of iron or steel is called *Induction*. The magnet thus used to make another magnet does not lose any of its force.

438. *Magnetic substances* are such as are attracted by a magnet ; among them are iron, steel, nickel and cobalt, and in less degree magnetic are manganese, chromium, platinum, plumbago and oxygen.

439. Certain substances exhibit a remarkable property in reference to magnetism. If suspended between the poles of a powerful magnet in the shape of a horseshoe, they assume a position at right angles to the line joining the poles, as if they were repelled by both poles. Phosphorus, bismuth,

antimony, zinc, tin, resin, and hydrogen act in this manner. Such substances are called *diamagnetic*.

440. Effects similar to those produced by a magnet may be produced by very simple means.

A stick of sealing wax rubbed with dry flannel has the property of attracting to itself small pieces of paper, shreds of cotton and silk, feathers, gold leaf, sawdust, and other light bodies. The stick of sealing wax having been negatively electrified by the friction produced by the flannel attracts light bodies. But the bodies attracted to the sealing wax become in turn *charged* with the same negative electricity and are then no longer attracted but repelled, so that they do not *fall* off the wax but are really *thrown* off.

A warm glass rod rubbed with a silk handkerchief, or a silk pad, also attracts and afterwards repels light bodies; but the glass is *positively* electrified.

The polarities of the wax and the glass rod are opposite, and hence the bodies repelled by the one are attracted by the other.

Two bodies charged with like electricities repel each other; but two bodies of opposite electrical polarities attract each other.

441. Other phenomena of electricity which may be readily produced are these:

A hard rubber comb attracts the hairs to itself in the act of being used.

If you put a piece of zinc upon the tongue and a silver coin under it no peculiar sensation is perceived if the metals are not in contact; but if you let the metals touch each other at the edge while placing your tongue between them, a singular, disagreeable, tingling sensation and taste is developed.

If you place a silver coin between the upper lip and the teeth instead of under the tongue, and the piece of zinc above the tongue, and then bring the two metals into contact with each other, the peculiar taste will be perceived as before, and, besides, there will be, each time, a momentary flash of light appearing to pass before the eye.

Light is emitted when a cat's fur is stroked in the dark.

All these are electrical phenomena.

442. *Conductors* of electricity are substances which readily transmit electricity from one body to another.

Substances that do not transmit electricity are called *non-conductors*, or *insulators*.

But these distinctions are only relative, for there are no perfect conductors, nor any perfect insulators.

443. Active chemism, or a chemical reaction (522), is always attended by the development of electricity. The electricity

thus developed is *dynamical electricity;* while identical with statical or frictional electricity, its discharge is continuous while the current of statical electricity is only momentary.

444.   Electric currents are commonly produced by chemical action between metals and corrosive liquids.

The *voltaic current* is thus produced when one strip of copper and another of zinc are placed in dilute sulphuric acid in a glass jar, the two strips of metal being connected, above the acid, by a wire, which serves as the conductor.   This apparatus is called a *voltaic, or galvanic, element or cell.*

445.   A number of voltaic cells connected so that the current has the same direction (446) in all, constitute a *voltaic battery.*

446.   *Direction of the Current.*—The positive current of electricity within the liquid is from the zinc to the copper (447), and above the liquid from the copper to the zinc, thus producing a *circuit.* To connect the plates by means of the metallic wires (copper wire is used), is called *closing the circuit,* and to separate them is to *break the circuit.*

447.   The current starts from the zinc because that is the metal most easily acted upon by the acid, and that metal is, therefore, called the *generating* plate, while the copper is the *conducting* plate.   The generating plate is also called the *positive plate* and the conducting plate the *negative plate.*

448.   Many different kinds of cells and batteries have been invented and several are in use, all based upon the fact that chemical reactions produce electricity.

449.   *Poles.*—If the wires be disconnected, or the current broken, the positive electricity will tend to accumulate at the end of the wire attached to the negative plate (the copper), and the negative electricity on the wire attached to the positive plate (the zinc).   The ends of the wires are called the *poles,* or electrodes, of the circuit.   The wire attached to the negative plate is the positive pole, and that attached to the positive plate is the negative pole.

450.   *Chemical effects* of the electric current.   If a chemical compound be placed between the poles or electrodes of a bat-

tery and thus made to form a part of the external voltaic circuit, chemical decomposition will take place. This process of decomposition is called *electrolysis*, and any substance capable of electrolytic decomposition is called an *electrolyte*.

Electrolysis proves a remarkably intimate analogy between electricity and chemism which will be referred to again.

451. Electroplating and electrotyping are performed on the principle of electrolysis, the metal being separated from its salt and deposited on the negative electrode, which may consist of the article to be plated provided it possesses a conducting surface.

PART II.
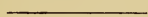
CHEMISTRY.

PART II.

CHEMISTRY.

CHAPTER XXIV.—Introductory.

MASSES, MOLECULES AND ATOMS.

452. The three great divisions of the material world are the **Animal Kingdom,** the **Vegetable Kingdom,** and the **Mineral Kingdom.**

All natural material objects around us belong to one or another of these three kingdoms. The artificial material things, which are the result of man's labor, may be made up of matter derived from two or all three kingdoms of Nature.

453. **Inorganic** or **Mineral Substances** are those belonging to or derived from the mineral kingdom. They include stones, earth, metals, and all chemical compounds, except the compounds of carbon and hydrogen and their derivatives.

The metallic salts, as the compounds of potassium, sodium, calcium, zinc, iron, mercury, lead, etc., and the " mineral acids," as sulphuric, phosphoric, nitric, hydrochloric and hydrobromic acids, are thus all *inorganic compounds.*

454. **Organic Substances** are those belonging to or derived from the animal and vegetable kingdoms, and the numerous derivatives of the hydrocarbons and many other carbon compounds.

All our plant drugs and animal drugs, together with the substances extracted from them, as alkaloids, gums, resins, etc., and all our fluid and solid extracts are among the organic substances. Acetic, oxalic, citric, and tartaric acids, tannin, santonin, sulphate of quinine, sugar, starch, alcohol, glycerin, ether, chloroform—all are organic substances.

455. By far the greater number of bodies in nature are made up of various substances in various proportions. They consist of unlike masses and unlike molecules mixed together. This is true of both organic and inorganic bodies. It is strikingly evident that all animal bodies consist of many different substances, some solid and some liquid, some hard and others soft, some of one color and others of another color, etc. Plant tissues, as wood, etc., also consist of many different things. These are, therefore, *heterogeneous masses,* or *mixed substances.*

456. But there are also many bodies which appear, even upon close examination, to have a perfectly *homogeneous mass* throughout. Water is thus uniform. It appears to be of perfect sameness in every minutest particle of its mass; and, in reality, *it is* but one substance or kind of matter. A large number of minerals, ores and metals also appear to be, and really consist of but one kind of matter throughout their mass. Other bodies, again, which have the appearance of perfect sameness in their every least particle, nevertheless consist of more than one kind of matter, as is the case with air, solutions and mixtures of certain liquids.

457. If a piece of sugar be put in a tumblerful of water, the sugar dissolves and the sugar and water form a solution, in which they are so intimately blended that every drop of the liquid is precisely like every other drop, and it is impossible to distinguish the particles of water from the particles of sugar in that liquid. Yet, we can separate the water from the sugar, for the water is vaporizable, while the sugar is fixed; and, hence, the water can all be evaporated, leaving as a residue the whole amount of sugar which we put into the water. Therefore, the water and sugar must have been blended or intermingled with each other without losing their respective identities, every particle of either of them remaining wholly distinct from every particle of the other, although we could not *see* this to be the case, the particles being too minute to be perceptible, even with the aid of the most powerful microscope.

458. If you mix together, by trituration, in a mortar, one scruple of calomel and one scruple of sugar, the result will be a mixture so perfect that it looks as if it were but one substance. But if you mix this powder with an ounce of water in a dish; pour off the water which washes out the sugar by dissolving it; repeat the washing with fresh portions of water until the water no longer acquires any sweetish taste, and then let the residue dry, and weigh

it, you will find that residue to be the one scruple of calomel. The sugar and the calomel were neither of them lost or altered by being triturated together, but were only mixed, and their separation was easily accomplished by simple physical means.

459. If you mix an ounce of alcohol and an ounce of glycerin, the mixture looks quite as uniform as water; but if you heat the mixture in a dish over a water-bath a sufficient time, all the alcohol will be driven off, and the glycerin will all remain in the dish.

460. Mix 20 grains of each of magnesia, sugar, rosin and charcoal, and reduce all to a uniform fine powder. It looks as if it were but one substance. Now mix it with enough water to make a thick fluid; transfer this to a paper filter in a small glass funnel; rinse the mortar and pestle with a little more water so as to get all of the powder added to the rest on the filter. Collect the liquid which runs through the filter; evaporate it to dryness and weigh the residue. Let the filter and contents dry. Then add to the powder in the filter just enough alcohol to moisten both the filter paper and contents, and, after a few minutes, add enough alcohol to cover the whole of the black mass in the filter, and collect all of the liquid that passes through, and evaporate it to dryness and weigh the residue. Allow the filter and contents to become nearly dry again, and then treat the remainder of the mixture in the filter with a mixture of sixty minims of diluted sulphuric acid and one-half fluid ounce of water in the same manner as you before treated the contents of the filter with alcohol; collect the liquid that passes through and evaporate it to dryness. Then wash the residue on the filter with two fluid ounces of water by pouring that water into the filter on the contents and letting it run through. Collect this filtrate also and evaporate a portion of it to dryness.

Now, examine your several residues. You will find, if you have done your work well, and used enough of the water in the first, and of the alcohol in the second washing, that the first residue is your sugar, and the second residue is your rosin. The third residue, however, is neither sugar, rosin, magnesia nor charcoal, but a bitter white substance, soluble in water, quite unlike magnesia; it is, in fact, Epsom salt, and weighs over seventy grains. The last wash water will leave no residue, and if you now put the filter and contents in a dish over the water-bath and dry them perfectly, you will find that when they are put on the pan of the balance their total weight is about twenty grains, in addition to the weight of a paper filter of the same size as used in your experiment; that will account for your charcoal, which all remains in the filter to the last. If you taste the sugar, burn the rosin, and also subject the charcoal to such simple physical tests as you can think of, you will conclude that they are these substances and no other.

In this experiment it is shown that the original mixture of the four powders contained at least the sugar, rosin and charcoal unchanged. Indeed,

the magnesia, too, was unchanged in that mixture, but the sulphuric acid turned it into Epsom salt, which is water soluble, and it was thus separated from the charcoal. This change of the magnesia to Epsom salt was a *chemical change.*

461. But sometimes it is very difficult to determine by physical means whether or not a body is a mixture of different substances, or but one single substance.

462. All kinds of matter consist of one or more kinds of *atoms* united into *molecules.*

463. **Atoms,** as already stated (20), are the smallest particles into which any kind of matter can be sub-divided. Thus they are the absolutely indivisible particles of matter, of which all molecules and masses are made up. They are the smallest particles of matter which can take part in chemical reactions (522) or combinations. As atoms are indivisible, they are, therefore, of course, also undecomposable.

An atom can pass simply from one molecule to another, or a group of atoms liberated from one molecule may be re-arranged into other molecules; but it is held that no other atom can *continue* to exist singly independently, or alone, or in a free state, or uncombined with some other atom or atoms.

464. **Kinds of Atoms.**—Only seventy-two different kinds of atoms, or seventy-two kinds of undecomposable matter are so far known to exist. Two of these are *Argon* and *Helium,* discovered so recently that their properties have not yet been fully determined. They are gases.

465. The seventy kinds of atoms heretofore known are enumerated in the following

TABLE OF ELEMENTS AND THEIR SYMBOLS.

Aluminum	Al	Cæsium	Cs
Antimony (Antimonium		Calcium	Ca
or Stibium)	Sb	Carbon (Carboneum)	C
Arsenic (Arsenum)	As	Cerium	Ce
Barium	Ba	Chlorine (Chlorum)	Cl
Beryllium (See Glucinum)	Be	Chromium	Cr
Bismuth (Bismuthum)	Bi	Cobalt (Cobaltum)	Co
Boron	B	Columbium	Cb
Bromine (Bromum)	Br	Copper (Cuprum)	Cu
Cadmium	Cd	Didymium	Di

Erbium	Er	Potassium (Kalium)	K
Fluorine (Fluorum)	F	Rhodium	Rh
Gallium	Ga	Rubidium	Rb
Germanium	Ge	Ruthenium	Ru
Glucinum	Gl	Samarium	Sm
Gold (Aurum)	Au	Scandium	Sc
Hydrygen (Hydrogenium)	H	Selenium	Se
Indium	In	Silicon (Silicium)	Si
Iodine (Iodum)	I	Silver (Argentum)	Ag
Iridium	Ir	Sodium (Natrium)	Na
Iron (Ferrum)	Fe	Strontium	Sr
Lanthanum	La	Sulphur	S
Lead (Plumbum)	Pb	Tantalum	Ta
Lithium	Li	Tellurium	Te
Magnesium	Mg	Terbium	Tb
Manganese (Manganum)	Mn	Thallium	Tl
Mercury (Hydrargyrum)	Hg	Thorium	Th
Molybdenum	Mo	Tin (Stannum)	Sn
Nickel (Niccolum)	Ni	Titanium	Ti
Niobium (see Columbium)	Nb	Tungsten (Wolframium)	W
Nitrogen (Nitrogenium)	N	Uranium	U
Osmium	Os	Vanadium	V
Oxygen (Oxygenium)	O	Ytterbium	Yb
Palladium	Pd	Yttrium	Yt
Phosphorus	P	Zinc (Zincum)	Zn
Platinum	Pt	Zirconium	Zr

The name Beryllium is now obsolete, the name Glucinum having taken its place. The name of Niobium has been changed to Columbium. Finally Didymium has been recently split up into two kinds of atoms called Neo-didymium and Praseo-didymium. Thus the different kinds of atoms in the preceding table are seventy in number.

466. Endless as is the variety of substances, all material bodies in Nature, so far as at present known, are aggregations of molecules (470), each made up of one or more of this limited number of atoms (465).

467. Atoms are endowed with *chemical energy* caused by a force called *chemism*, or chemical force. Chemism is also called *combining power, chemical attraction, chemical affinity* and *atomic attraction.*

Atoms are united with each other by this force into molecules, and can not be separated from these molecules unless under such conditions that they may immediately form new molecules.

468. All atoms of the same kind have the same size and the same weight. But atoms of different kinds have different

weights. The absolute weight of any atom is unknown; but its relative weight, being constant, can be determined in several different ways with great accuracy.

469. Whenever any two or more atoms unite with each other by virtue of the chemical attraction between them, and their chemical affinities are thus satisfied or neutralized, a *molecule* (470) is the result.

When the atoms thus unite, their chemical affinities are spent or satisfied. Molecules, therefore, have no chemical energy or affinity, and can consequently continue in independent existence.

470. Molecules, as already stated elsewhere (16), are the smallest particles of any kind of matter that are capable of continued existence as such. They are the smallest particles into which any kind of matter can be divided without losing its identity, or without being thereby converted into some other kind or kinds of matter; for when molecules are divided into their constituent atoms they cease to exist, and the atoms form new molecules.

471. Masses are made up of molecules. Molecules are either *elemental* or *compound*.

Elemental molecules consist of atoms of but one kind.

Compound molecules are composed of more than one kind of atoms.

472. Elements are substances consisting of elemental molecules (471).

In an element, therefore, the mass, the molecule and the atom each consist of one and the same kind of matter.

The elements, therefore, can not be decomposed into other kinds of matter.

There are accordingly as many elements as there are different kinds of atoms. Thus, seventy elements are at present recognized (465).

Upon examination of the table of elements (465) you will find in it all of the known metals. In fact, about four-fifths of the elements are metals.

Of the whole seventy only five elements are gases at the common temperatures, two are liquids, and all the others solids.

473. Chemical compounds are substances consisting of but one kind of compound molecules (471).

Any substance containing more than one kind of molecules is not a definite chemical compound but is a mixed substance (482).

We have learnt that there are but seventy different kinds of matter called elements; *all other distinct kinds of matter are chemical compounds*, or *compound matter*.

474. Chemically homogeneous bodies are such as consist of but one kind of molecules, whether elemental or compound. All elements and all chemical compounds are therefore chemically homogeneous.

475. As all masses of matter are made up of molecules, and the molecules are the smallest particles into which matter can be divided without being changed into some other kind or kinds of matter (470), the mass is divisible into molecules without change of kind, but the molecule can not be split up into its constituent atoms without ceasing to be the same kind of matter (15 and 17).

476. Number of kinds of matter.—There are as many distinct kinds of matter as there are different kinds of molecules and *vice versa*.

They are countless.

477. Each molecule of any one chemical compound invariably contains the same total number of atoms, the same kinds of atoms, and the same number of each kind of atoms, and all its atoms are always in precisely the same positions relative to each other.

478. No two bodies or masses can both consist of one and the same kind of molecules without being the same kind of matter.

479. All molecules of the same kind have also the same size and the same weight; and all molecules whatsoever, whether of the same kind or not, have the same volume when in a state of vapor.

480. Each chemical compound, because it has precisely the same chemical composition and structure (477) under all circumstances, has also precisely the same chemical properties; and, moreover, each distinct kind of matter has uniformly the same physical properties under the same conditions.

481. Any two or more bodies having the same chemical and physical properties must consist of the same kind of matter.

482. Mixed substances, or *heterogeneous masses*, are bodies consisting of more than one kind of molecules. A mixture, or mixed substance, is made up of as many different substances as there are different kinds of molecules in it.

483. Recapitulation.—Every body or mass of matter of whatever kind is an aggregation of molecules. These molecules are held together by cohesion if of the same kind, but by adhesion if of different kinds.

Each molecule is the smallest individual particle of any kind of matter having the properties of the whole mass, and, therefore, the smallest particle of any kind of matter that is capable of subsisting.

In any one distinct kind of matter every molecule is like every other molecule and like the whole mass.

There are as many different kinds of matter as there are different kinds of molecules, and no more.

Every molecule of any one particular kind has exactly the same weight and the same volume as every other molecule of the same kind ; and all molecules of the same kind, moreover, contain each the same number of atoms, the same kinds of atoms, the same number of each kind of atoms, and the same internal atomic structure or grouping of the atoms.

All molecules of whatever kind, when in a state of vapor, have the same volume.

As the kind of matter is determined by the composition and structure of its molecule, any change in the composition or structure of its molecule involves the change of that kind of matter into a new or different kind or kinds of matter.

All molecules are made up of atoms united by chemism.

There are seventy different kinds of atoms.

Atoms are absolutely indivisible particles of matter.

All atoms of the same kind have the same weight and the same volume.

The different kinds of molecules or different kinds of matter are countless; yet they all consist of one or more of the seventy different kinds of atoms, so far as at present known.

When atoms of but one kind form molecules, the resulting molecules are simple kinds of matter, or *elements;* there are, consequently, as many different elements as there are different kinds of atoms, and no more.

But when unlike atoms, or atoms of different kinds, unite, the molecules thus formed are *compound matter*.

A chemically homogeneous mass is a mass composed of but one kind of molecules. Such a body is called a definite chemical substance. If all the molecules of such a mass consist of but one kind of atoms, the mass is that of an element; if they consist of more than one kind of atoms, the mass is that of a definite chemical compound.

But the greatest number of material objects or bodies in nature have masses composed of different kinds of molecules, and are not chemical compounds but only mixtures, each ingredient of which is distinct from every other ingredient in it.

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484. Physical Properties.—The physical properties of matter are those which belong to their masses and molecules. They include among others the form, state of aggregation, consistence, specific weight, vapor density, specific volume, color, odor, taste, solubility, melting point, congealing point, boiling point, etc.

485. Physics is that part of physical science (486) which concerns the states and changes of matter without (outside of) the molecules, and thus the physical properties (484). But

physical changes can not involve the essential physical properties of matter because they do not affect its identity or kind.

Physics is the scientific study and knowledge of molar and molecular matter.

486. **Physical Science** is the systematic pursuit and classification of all knowledge of matter and of the forces by which matter is affected.

It takes cognizance of the bodies of matter, the conditions, motions and changes to which these bodies are subject, and the laws governing the phenomena of physics and chemistry.

487. The **Chemical Properties** of matter are those properties which depend upon its atoms alone. They include the relative weights, valence (607), chemical energy (514) and electrochemical polarity (564) of the atoms; and the relative weights, structure, and analytical and synthetical reactions (522) of the molecules.

488. **Chemistry** is that part of physical science which treats of the structure and changes of matter *within* the molecule.

It is the science of the constitution and relative stability of molecules.

It is the scientific study and knowledge of atomic matter.

CHAPTER XXV.

CHEMICAL PHENOMENA.

489. **Chemical Phenomena.**—We have learnt (27) that matter is *indestructible*, or that it can not be annihilated. By the agency of chemism one kind of matter can be *transformed* into some other kind or kinds of matter; but it can not be changed as to its amount. The amount of matter in the universe can

neither be added to nor diminished, for it is uncreatable as well as indestructible.

490. Any substance may undergo change, and this change may be so great as to involve loss of identity; but in every such case the *matter* of which that substance was composed has not been destroyed but has simply been transformed into some other substance or substances.

When alcohol burns it disappears from sight, and *as alcohol* it no longer exists. But the *matter* of which the alcohol was constituted has not been destroyed. The elements of which alcohol is composed are carbon, hydrogen and oxygen; these three elements are capable of forming numerous compounds with each other and alcohol is one of these compounds. When alcohol is ignited it is *decomposed* by the combustion, and its carbon, hydrogen and oxygen, together with a certain amount of oxygen from the air, pass into other combinations—carbon dioxide and water—which are invisible in the gaseous state assumed by them when formed by the combustion of the alcohol in the air.

491. Whenever any substance is, as we say in common parlance, totally *destroyed* by fire, that substance may so completely lose its identity or its properties that it can no longer be recognized, and indeed is no longer the same substance; but instead of being lost or annihilated it has been *transformed* into other kinds of matter, and if the apparent destruction of the substance be accomplished under such conditions that the new products formed out of the substance so destroyed can be collected and weighed it is found that every particle of the original substance can be accounted for as entering into these new products.

492. Any two or more chemically homogeneous bodies (474) exhibiting, respectively, different properties can not severally consist of the same kind of molecules.

493. Whenever any body acquires permanently different properties by being subjected to the action of heat, light, air, moisture, or an electric current, or by contact with another body, or from any cause whatsoever, it has ceased to be the same kind of matter as before. It has been converted into some other kind of matter, or undergone a *chemical change*, or *chemical reaction*, or *chemical decomposition*, and these changes, reactions, or decompositions are *chemical phenomena*.

494. No two or more different kinds of matter have pre-cisely the same physical properties in all respects.

Whenever any kind of matter is changed as to its kind it is also changed as to its physical properties.

Mere mixtures or heterogeneous masses may, however, be changed as to their properties without loss of identity of the several ingredients ; any admixture changes the character of the whole.

495. Among the physical properties of matter are form, color, odor, and taste. Any one kind of matter always has the same physical properties under the same (or unchanged) conditions.

Lead iodide is always yellow. A yellow color does not prove that the substance having that color is lead iodide ; but the absence of the yellow color does prove that the substance is *not* lead iodide

Ammonia has a peculiar, strong odor. Any substance which does not possess that odor can not be ammonia.

An acid liquid can not be sugar, for sugar is a solid and has a sweet taste.

Salicin can not be mistaken for potassium iodide, for salicin consists of bitter, silky, slender crystals, while potassium iodide has a pungent, saline taste and crystallizes in cubes.

A water soluble solid can not be calomel, nor can a crystalline precipitate be castor oil.

496. A change produced in the physical properties of bodies accompanies any chemical change which they may be made to undergo.

Indeed striking changes in the color, odor, or other physical properties of a body generally denote that it has been con-verted, in whole or in part, into some other kind of matter.

497. Many chemical changes proceed quietly and unac-companied by any marked physical signs, but many other chem-ical changes are attended with striking physical phenomena, such as fire, explosion, etc.

Fire is always the result of chemical reaction.

Explosions of gun powder, dynamite, gun cotton and gas, are caused by chemical reactions.

Other less noisy and less dangerous evidences of chemical change are exhibited in the following experiments.

498. Put two or three little crystals of chromic acid on a piece of paper; put about fifteen drops of alcohol in a graduate or bottle, then pour that alcohol over the crystals, and observe the commotion that instantly follows. The heat liberated by the reaction ignites the alcohol; hence, it is safer not to add the alcohol out of the shop bottle, but to put the small amount required in another vessel before adding it to the chromic acid.

499. Put a little diluted sulphuric acid in a graduate and add to it a little potassium carbonate; a lively effervescence takes place and the mixture becomes warm.

500. Place about half a teaspoonful of each of potassium carbonate and ammonium chloride in a mortar. Observe before they are mixed that neither of them has any odor. Then rub them together and note that the odor of ammonia is developed.

501. Mix four grains of corrosive sublimate in a mortar with five grains of potassium iodide; the materials are both white, but the mixture will be scarlet red.

502. Touch a little diluted sulphuric acid with the end of your tongue and observe how acid it tastes; taste also a little magnesia, and notice that it has only a faint, earthy taste. Then put two fluid-drachms of the diluted sulphuric acid in a graduate and add one drachm of magnesia; stir well, and when the liquid no longer dissolves any more of the white powder taste the liquid. You will find that it is neither acid, nor of a faint, earthy taste; it is, instead, of a cooling, saline, bitter taste.

503. Dissolve a grain of blue vitriol, or copper sulphate, in two ounces of water; observe that the color is very pale bluish; add a few drops of ammonia water and see how the color changes to a beautiful deep blue, which does not belong to either water, copper sulphate, or ammonia, but to a new substance formed in the liquid.

504. Dissolve one-half grain of sodium salicylate in a half-pint of water; add a few drops of tincture of chloride of iron and observe the reddish or purplish color produced in the mixture; now add about a fluid-ounce diluted hydrochloric acid and the color disappears again.

505. Dissolve thirty grains of pure sulphate of iron (or of clear, green crystals of copperas) in half an ounce of water, and dissolve fifteen grains of oxalic acid in another half ounce of water; mix the two solutions and observe that a yellowish color first makes its appearance and afterwards a yellow powder is found in the liquid.

506. Mix one fluid-drachm of tincture of chloride of iron with two fluid-drachms of ammonia water and observe that a copious brown-red precipitate is formed.

507. Mix one fluid-drachm of tincture of chloride of iron with two fluid-drachms of simple syrup, and then add two fluid-drachms of ammonia water;

observe that no precipitate is formed, but a deep brown red color is produced. Compare this experiment with that described in the preceding paragraph.

508. Put a fluid-drachm of syrup of iodide of iron in a graduate and add a little solution of potassa; observe the deep green color brought out

509 Put one fluid-drachm of tincture of iodine in a one-ounce bottle; add about fifteen minims *stronger* water of ammonia and one drop of carbolic acid; shake; observe that the dark iodine color soon disappears, leaving a colorless liquid.

510. The experiments described in paragraphs 498 to 509, inclusive, are all examples of chemical reactions accompanied by evident physical signs, such as fulmination, effervescence, the development of odor, changes of color, change of taste, the discharge of color and the formation of insoluble substances in liquids.

The results of these experiments are sufficiently striking to excite interest in the causes and effects. And yet how feeble they are beside the wonderfully active chemical reaction which we call fire, or the explosion of the charge in a gun!

511. There are numerous examples of slow chemical changes or reactions all around us which we may witness if we are observing.

A bright iron nail exposed to air and moisture will rapidly become rusty; the rust is an iron compound formed by chemical reaction, and to recover the iron again from that rust requires a chemical process.

Bright copper or brass turns green when acted upon by air and grease, or by vinegar; the green compound is a product of chemical action.

When limestone is heated in a kiln, it is decomposed and quick lime remains; if the quick lime is mixed with water it becomes slaked, heat is generated by the chemical action, and the white liquid which results does not contain quick lime but calcium hydrate. Both changes are chemical.

When copperas is exposed to the air it becomes brown on the surface; the brown substance is not copperas but another compound formed by chemical action.

Nitrate of silver and yellow oxide of mercury darken on exposure to light as a result of chemical decomposition.

Fermentation, by which malt, syrup and sugar yield alcohol, and by which weak alcoholic liquids, like cider and weak wines, turn into vinegar, is a chemical process. The change by which the rich green of the foliage of our forests is changed to the beautifully varied hues of autumn leaves, is also the result of chemical reactions.

The decay of wood and other organic substances, the putrefaction of animal matter, the digestion of food—all these are chemical processes, involving chemical changes; produced by chemism, and resulting in the decomposition of the old molecules and the formation of new ones in their places.

512. Relative Stability of Molecules.—Some substances resist chemical influences and changes to a remarkable degree. The molecules of platinum, gold, quartz, clay, carbon, and many other substances remain unaltered under ordinary conditions. On the other hand, there are also numerous substances which are easily affected by air, moisture, changes of temperature, the influence of light, or by contact with other substances.

513. Chemical Changes or Reactions or phenomena are those changes in matter which extend not only to its physical properties, but which involve the very identity of its kind.

So long as the molecule is unchanged, the matter of which it consists remains of the same kind, but when the molecule is divided or decomposed, or its interior structure altered, that change is a chemical change or reaction, because it changes both the physical properties and the kind of the matter.

CHAPTER XXVI.

CHEMISM.—ITS INTENSITY, QUALITY, AND QUANTITY.

514. Chemism is the force which manifests itself by atomic attraction and repulsion, and by which molecules are formed, altered or decomposed.

It is the force by which matter is altered as to its kind. The transformation of any kind of matter into any other kind or kinds of matter is effected by chemism, and never directly by any other cause (515).

515. Matter may be altered as to its kind, or its alteration may be prevented, apparently by other agencies than chemism, but only in an indirect way.

Heat, light and electricity cause chemical changes to take place; but only by aiding chemism, or by producing conditions favorable to the action of chemism.

Chemism may be aided or opposed by other forces, and may be converted into other forms of energy, or other forms of energy may be converted into chemism. But that energy which changes matter as to its kind is always and alone chemism.

516. All atoms are endowed with or subject to chemism. It is because of this irresistible force that atoms can not subsist singly or uncombined, but are compelled to seek new partners as soon as they are liberated from their previous partnership in some other molecule, and can thus only pass from one molecule to another.

517. In thus causing and directing the separation, union, or rearrangement of the atoms, the chemism of these atoms is neutralized, or saturated, or rendered latent. All molecules are, therefore, neutral.

Chemism operates only between atoms; never between molecules.

518. But changes of matter from one kind to another kind would be impossible were it not for the separation of atoms from each other and their re-arrangement into new molecules. It therefore follows that atoms *must* be made *free* before they can be again tied to or combined with other atoms. At the moment of their transfer from one molecule to another they are free and endowed with active, unsatisfied combining power or chemism.

519. Radicals. Atoms and groups of atoms whose chemism is wholly or partly unsatisfied are called *radicals*.

A *simple* or *elemental radical* is a single atom in a free state, or with all its chemical combining power in full play. All atoms in a free state are simple radicals.

A *compound radical* is a group of two or more atoms of different kinds, tied together by a part of their chemism, but having another part of their chemism still unsatisfied. The atoms in such a group act together as one radical, or as if the whole group were but one atom.

Radicals, then, are atoms or groups of atoms liberated from molecules, and impelled by chemism to unite with other radicals to form new molecules.

520. Radicals differ as to the intensity, quality and quantity of their chemism.

By *intensity* of chemical energy is meant the relative power of the affinity of one radical as compared with that of another (521).

The *quality* of the chemism of any radical is indicated by the character and conduct of the compounds it forms, and depends upon its electro-chemical polarity (564).

The relative quantity of the chemism of a radical is expressed by the term *valence* (607).

521. The relative energy or intensity of chemism is in many instances very marked. Radicals unite according to their mutual attractions or affinities. The attraction between some radicals is relatively stronger or weaker than the attraction between other radicals.

Thus the chemical affinity between potassium atoms is weaker than the affinity of potassium atoms for the atoms of oxygen, and phosphorus atoms have a greater affinity for hydrogen atoms than they have for nitrogen atoms.

Hydrogen conducts itself as a neutral or chemically indifferent substance under ordinary conditions.

Chlorine, however, attacks other substances with great energy.

Sulphuric acid is far more energetic in its chemical action than boric acid; the sulphuric acid is extreme'y corrosive and destructive, while boric acid is a harmless, inactive substance.

522. **Chemical Reactions.**—Any change which takes place within a molecule is a chemical reaction.

Molecules differ according to the kind, number and relative position of their atoms. Any change in either of these respects is a chemical reaction. The removal of one or more atoms; the addition of one or more atoms; the change of one or more of the atoms by substituting others of a different kind; or any inter-atomic re-arrangement within the molecule by which the relative positions of the atoms is altered—either of these changes is a chemical reaction.

523. **The Factors of the Reaction** are the molecules decomposed in any chemical reaction.

The Products of the Reaction are the new molecules formed by it.

Thus when iodine and mercury are triturated together in a mortar to make iodide of mercury, the iodine and the mercury are the *factors* and the iodide of mercury the *product* of the reaction which takes place.

When a solution of acetate of lead in water is mixed with a water solution of sulphate of zinc, a white insoluble powder precipitates in the liquid, which is sulphate of lead, while water-soluble acetate of zinc remains in solution. In this case the acetate of lead and the sulphate of zinc are the *factors* of the reaction, and the sulphate of lead and acetate of zinc are its *products*.

524. Reagents.—The factors of a reaction are also called *reagents*. But the term reagent is more especially applied to substances employed for the purpose of identifying compounds, radicals or elements, by means of reactions accompanied by striking results and produced by the reagents added for that purpose. Reagents are, therefore, used in analytical processes (525).

525. Chemical reactions are **synthetical** when their object is to obtain certain products; they are **analytical** when their object is to identify substances, or detect their presence, or to determine their composition.

526. Synthesis is the formation of compounds by bringing together the radicals necessary to their production under such conditions as are favorable to the synthetical reaction desired.

It is the opposite of analysis.

Direct synthesis is the formation of but one kind of molecules from two or more kinds, as when iodide of mercury is prepared from the elemental molecules of iodine and mercury, or when hydrochloric acid and ammonia unite to form ammonium chloride.

Indirect synthesis is illustrated by substitution (842) and by double decomposition (529), as in the formation of acetate of zinc from acetate of lead as described in par. 523. More than one kind of molecules are produced by indirect synthesis.

527. Analysis.—The decomposition of chemical compounds for the purpose of determining their composition is called chemical *analysis*.

The analysis is *qualitative* when the object is simply to identify the radicals or elements of which a substance is composed

without attempting at the same time to ascertain the quantities of the component elements or radicals.

Quantitative chemical analysis has for its object the determination of the exact quantities of the elements or radicals of which molecules are composed, or the exact quantities of each of several kinds of molecules contained in any mixture, solution, ore, or other mixed substance.

528. Chemical Decomposition is the separation of the constituent radicals or atoms of a molecule.

When mercuric oxide is heated above 360° C. (680° F.) it decomposes into mercury and oxygen, its constituent elements. When calcium carbonate is heated to redness it decomposes, or splits up, into two new compound molecules, one of which is calcium oxide and the other carbon dioxide.

Chemical decomposition may result from the reaction of two or more substances upon each other, or a re-arrangement of the atoms within a molecule may be indirectly induced by external causes as by the influence of heat, light, or electricity.

529. Double Decomposition results when two compound molecules are brought together which mutually decompose each other, the reaction giving rise to two or more new compounds.

CONDITIONS FAVORABLE TO CHEMICAL REACTION.

530. Actual contact between the particles of matter is necessary to chemical action.

531. Sometimes dry substances may be made to unite chemically by simply *triturating* them together, as when iodine and mercury, or sulphur and mercury, are combined, forming iodide or sulphide of mercury. But this is rarely sufficient.

532. When the factors of the reaction are both gaseous, the chances are usually more favorable to a complete reaction than when they are solid. But oxygen and hydrogen can be mixed and the mixture kept for a long time without any chemical reaction taking place; and a mixture of chlorine and hydrogen can also be kept without change, although the chemical attraction between these gases is very strong. An electric spark, or the application of a lighted match, will quickly cause the gases to unite with violent explosion. The chlorine and hydrogen

may react with explosion even by the influence of direct sun-light, but not if the mixture be kept in a shaded place.

533. The most favorable condition in which the factors of the reaction can be as to the state of aggregation is the liquid condition. At least one of them should, therefore, be liquid if possible, and it is still better to have both factors of the reaction in that state.

534. Solids can be rendered liquid either by fusion or by solution, some by one method, some by the other, and still others by either method. But, for the purpose of facilitating chemical reaction, solids are liquefied by fusion only in cases where that is the only practicable means (by reason of the insolubility of the solids or for other reasons).

535. Whenever it is possible to bring the factors of the reaction together in a state of solution, that is the method pur-sued, because in that condition they can be more intimately mixed, and react more freely, uniformly and completely.

536. Heat opposes and often overcomes chemical attraction. It is, therefore, destructive to most kinds of matter. Compar-atively few kinds of matter can resist the action of strong fire, and numerous substances are decomposed at temperatures not exceeding those readily produced by very simple means. But even when the heat is insufficient to break up a molecule, it, nevertheless, weakens the force with which the atoms are held together, just as heat weakens the cohesion of a mass by increas-ing the distances between the molecules.

537. Thus heat causes chemical reactions in such a way that it seems to aid chemical attraction, although the opposite is true. Heat disrupts existing molecules by causing their atoms to separate from each other. But when the molecules have been decomposed by heat, the atoms of which they were constructed at once rearrange themselves into new molecules capable of resisting the high temperature. Heat indirectly facilitates certain chemical reactions by giving free play to the selective affinities of the atoms whose bonds (615) have been severed by its repellant force.

538. Action of heat upon salts.—Salts containing water lose that water when heated.   Water of crystallization is usually expelled already at or even below 100° C.; in some cases the salts thus heated dissolve in their water of crystallization before they lose it.   Thus a crystal of sodium phosphate is liquefied by heat forming a solution in its water of crystallization.   Solution of this kind is called *aqueous fusion.*

Many anhydrous salts undergo fusion at high temperatures; to distinguish this from " aqueous fusion " it is called *igneous fusion* or dry fusion.

Heat causes the decomposition of many salts, especially of those of volatile or unstable acids or bases, except in cases where a strongly positive radical is united to a strongly negative one.

Thus the carbonates are generally readily decomposed by heat, except the carbonates of the alkali metals.   Chlorates and nitrates are easily decomposed by heat, but phosphates and borates resist it: sulphates of the heavy metals are decomposed, but the sulphates of potassium, sodium, barium and calcium are not.

539.   Chemism generates heat.—Heat is always liberated by chemical action.   More or less heat must frequently be applied to induce chemical action; but the heat afterwards generated by the reaction itself is often sufficient to maintain the energy of chemism.

This fact is well illustrated in our experience with the making of fires; the wood or coal must be heated up to a certain point before active combustion goes on, after which the fire continues as long as the supply of fuel and air is sufficient.

540.   When heat weakens the atomic attraction within a molecule without breaking it up entirely, the contact of that molecule with another molecule of a different kind may prove to result in a reaction even if such action would not take place without the aid of the heat, both means being necessary to bring it about.

541.   Electricity decomposes many chemical compounds, and, therefore, also indirectly causes the formation of other compounds to take the place of those decomposed by it, just as in the case of the decomposition of molecules by heat.

542. Status nascendi.—Chemical reactions take place far more readily when the reacting elements or radicals come into contact with each other at the instant they are liberated from other compounds.

Sulphur and hydrogen do not combine directly; but when both are simultaneously displaced from their compounds—sulphur from iron sulphide and hydrogen from sulphuric acid—they readily unite forming hydrogen sulphide.

543. Molecular hydrogen has no chemical energy; but atomic hydrogen is energetic enough to decompose nitric acid.

If hydrogen be generated in one vessel, and passed through a tube into another vessel containing nitric acid, the gas (molecular hydrogen) will have no effect whatever upon the nitric acid no matter how long continued the current of hydrogen may be. But if hydrogen be slowly generated *in the nitric acid itself* by dissolving metallic iron in the cold dilute acid, no evolution of gas takes place although hydrogen is set free from the nitric acid, iron taking its place in the molecule of the acid, because the *nascent hydrogen*—the atomic hydrogen at the moment of its liberation and before its atoms unite to form molecules—decomposes another portion of the nitric acid forming ammonia and water ($HNO_3 + 4H_2 = NH_3 + 3H_2O$) so that the resulting solution will finally contain not only iron nitrate but also ammonium nitrate.

544. Chemical reactions are also affected by physical forces, both as to their energy and their direction.

Cohesion and *adhesion* exert an important influence upon the course of chemical reactions, in both *dry processes and wet processes* (545 to 547).

545. Dry processes or methods are those in which the factors of the reaction are dry substances, either in powder, pieces, or in a state of fusion.

Thus when preparations are made by trituration, fusion, exsiccation, calcination, sublimation, etc., they are said to be made by the "dry way."

546. Wet processes are those in which one or both factors of the reaction are in a state of solution.

All precipitates are prepared by the "wet way," and also many of the water soluble salts.

547. In wet processes involving double decomposition (529) —that is, when reactions are induced between substances in a state of solution—the direction, velocity, and completeness of

the reaction depend greatly upon the relative solubilities of the products.

In dry processes where heat is applied, the reaction which takes place, if any, and, indeed, the very question whether any reaction will ensue or not, depends in many cases upon the state of aggregation or cohesion of the possible products—that is, upon whether or not the products are fixed or volatile substances.

548. The predisposing affinity of a third molecule is sometimes of great importance as a means of inducing chemical reaction between two other molecules. In other words A and B may not react with each other in the absence of adventitious influences, but may do so in the presence of another body, C, which stands ready to react with one of the products of the reaction between A and B.

The general tendency of all matter is to form as neutral and permanent molecules as possible under the conditions under which it is placed. A negative radical, therefore, determines or predisposes the formation of a positive one with which it may be united, and *vice versa*, in order that the final result may be a more firmly united and stable molecule. Strong acids and strong alkalies exert a destructive influence upon many neutral substances for this reason.

In chemical reactions which are accompanied by a change of the valence of elemental radicals, the cause of such a change can hardly be looked upon as any other than this predisposing affinity which compels the formation of the strongest possible compound radicals, that can be formed out of the atoms taking part in the reaction.

CHAPTER XXVII.

THE LAW OF OPPOSITES IN CHEMISTRY.

549. The opposite properties of acids and alkalies are among the most striking facts of chemistry. The destructive properties of both have been known since ancient times, and are so pronounced and so important as to be familiar to most per-

sons of the present time.   The sour, corrosive properties of the
stronger acids are opposite to the caustic properties of the alka-
lies, and acids and alkalies neutralize each other, so that the
properties of both are nullified.

These facts were observed long before chemistry assumed
the dignity of a science.

550.   Acetic acid in the form of vinegar is mentioned in the
books of Moses, and was used in medicine by Hippocrates and
Dioscorides.

Nitric acid was made by Geber in the seventh century, and
"muriatic acid" was also known at a very early period.   The
Arabs knew how to make "aqua regia," which is a mixture of
nitric and muriatic acids, and they were acquainted with the
fact that gold could be dissolved in that mixture.   "Oil of vit-
riol," which is an old name for sulphuric acid made from "green
vitriol," was made as early as the 15th century.

551.   The lye of wood ashes was well known, and the solid
"fixed alkali," which was obtained from it (the impure "pot-
ash").   Lime, too, had attracted attention, and its effect in
increasing the alkaline character of potash and soda.   Sodium
carbonate is referred to in the Old Testament, and the ancients
applied the name *nitrum* to it.   Ammonia was recognized as an
alkali, being known as a constituent of urine after standing
(and we still hear the expression "chamber-lye").   It was also
made from ammonium chloride, known at least as early as in
the 7th century.   Later, potash was called "alkali vegetabile,"
soda (sodium carbonate) was named "alkali minerale," and
ammonia, "alkali volatile."

552.   The fact that acids and alkalies neutralized each other's
corrosive properties was too striking to remain unobserved.
Acid and lye saturated each other and neutral compounds
resulted which had properties entirely different from those of
either of the materials which were mixed.

When vinegar was poured upon chalk, the chalk was dis-
solved and effervescence took place.   The gas which caused
this effervescence as it passed off received later the name of
"acid of air."

553. But it was further known that some acids and some alkalies are stronger than other acids and alkalies, respectively. It was recognized that sulphuric acid ("oil of vitriol") would decompose nitre, whereby nitric acid was obtained, and that it would also decompose common salt, whereby muriatic acid was gotten.

It is true the early chemists did not know the acids, bases and salts by their present names, and did not know their chemical composition and formulas; but they knew their striking differences.

554. The metals potassium and sodium were separated from the fixed alkalies by means of electricity by Sir Humphrey Davy; and the discovery of oxygen and chlorine, and of the true nature of combustion, led to a classification of the elements into the metallic and non-metallic groups, which further emphasized the opposite character of their most important compounds.

555. Acids (883) and bases (874) were carefully studied. It was discovered that both classes of compounds, as a rule, contained oxygen; but that the metallic oxides (846) were basic (848), whereas the oxides of the non-metallic elements (847), containing a comparatively larger proportion of oxygen, produced acids. Consequently the salts were assumed to be composed of metallic oxides with the anhydrides of the non-metallic elements, and potassium sulphate, which is now written $K_2 SO_4$, was then written $KO. SO_3$. What was then called an acid is now called an anhydride. But the main fact is—they were of opposite chemical properties and neutralized one another.

556. Simultaneously with the introduction of the balance and the discovery of oxygen came the researches and discoveries of Volta and Galvani in the field of electricity.

The intimate relations between chemism and electricity were recognized. Not only was the galvanic current produced and maintained by the aid of chemical reactions, but the current seemed to have an almost unlimited power to resolve chemical compounds into two constituents; one of which was invariably

attracted to the positive electrode and the other to the negative
electrode. Salts were thus decomposed with the result that the
acid collected at the positive pole, and the base at the negative
pole. Other compounds have been decomposed in the same
way and with similar results.

557. We have before learnt (443) that electricity is devel-
oped by chemical action, and that the electricity thus developed
is called *galvanic* or *voltaic electricity*, being so named after Gal-
vani and Volta.

We have also seen (435) that electricity exhibits in a striking
manner phenomena of attraction and repulsion, because it
has two opposite states, one called *positive electricity* and the other
negative electricity, and that electricity is a polar force with posi-
tive polarity and negative polarity (449).

It has also been stated that bodies charged with like elec-
tricities repel each other, while two bodies of opposite electrical
polarities attract each other (440).

558. No chemical reaction takes place without the develop-
ment of electricity. It is also known that chemical reactions are
essential to the production of voltaic action. The energy of the
electric current is proportionate to the energy of the chemical
action, and the direction of the one is dependent upon the
direction of the other.

559. Electrolysis.—A great number of compounds can be
decomposed into their immediate constituents by means of
electricity. This is called *electrolysis*. The various compounds
which can be decomposed by electrolysis are called *electrolytes*.

560. Electrolytic decomposition resolves the constituents of
the electrolyte into two groups, one of which is attracted to the
negative pole of the battery, the other passing to the positive
pole.

561. The same current of electricity, transmitted succes-
sively through different electrolytes, decomposes each in the
proportion of their respective chemical equivalents.

The energy of the electric current is proportionate to the
energy of the chemical action which produces it.

562. When a chemical compound is decomposed by an electric current, the matter attracted to the positive pole is said to be *electro-negative*, and that attracted to the negative pole is *electro-positive*.

563. The foregoing facts point strongly to a law of opposites in chemistry analogous to the law of opposites which is so strikingly manifest in the phenomena of electricity.

564. **Electro-chemical Polarity.**—Radicals are of two opposite kinds as to the quality of their chemism, namely, *positive* and *negative* radicals. Positive radicals unite with negative radicals, and negative radicals unite with positive radicals; but one positive radical does not unite with another positive radical; no radical unites with another radical of the same electro-chemical polarity.

565. **Positive radicals** are those which are attracted to the negative pole in electrolysis

They form compounds with the negative radicals.

566. **Negative radicals** are those which are attracted to the positive pole in electrolysis.

They unite with positive radicals to form chemical compounds.

567. **Electro-chemical Theory.**—The phenomena of chemism have been attributed to electrical attraction between atoms and between radicals.

That strong grounds for such an hypothesis exist is sufficiently evident from the foregoing. There are, however, a large number of compounds which do not seem to be susceptible of electrolytic decomposition.

The electro-chemical theory, and the idea of simple and compound radicals which is inseparable from it, do not so directly and plainly account for *substitution*, which results in changes within the radical, leaving the external behavior of the latter unaffected.

Yet, until a better hypothesis shall have been presented, the obviously intimate relations between electricity and chemism are recognized, simple and compound radicals are referred to as relatively electro-positive or electro-negative, chemical combination is regarded as dependent upon the opposite electro-chemical properties of atoms and compound radicals, and the general chemical character and conduct of compounds are supposed to be determined by the electro-chemical characters and relations of their constituents.

Berzelius assumed that atoms were endowed with *electric polarity* and that when two substances combine chemically their opposite electricities neutralize each other. This *electro-chemical* relation between acid-forming and base-forming simple or compound radicals applies to both inorganic and organic chemistry.

568. Molecules formed by the union of strong electro-positive radicals with strong electro-negative radicals offer greater resistance to change than other molecules.

Very complex molecules, containing a large number of atoms, and composed of several different compound radicals, are more frequently unstable than those of more simple structure.

569. But the terms " positive " and " negative," as applied to radicals, are only relative terms, for any one radical may be electro-positive with reference to some and electro-negative to other radicals of other kinds.

Thus when nitric anhydride, which is a compound of nitrogen and oxygen, is decomposed by an electric current, its nitrogen is collected at the negative pole and its oxygen at the positive pole of the battery; but when ammonia, a compound of nitrogen and hydrogen, is similarly decomposed, the nitrogen passes to the positive pole, the hydrogen going to the opposite electrode.

Sulphur is found to be electro-positive in sulphuric anhydride, a compound of sulphur and oxygen, but negative in its compounds with the metals.

570. The metals are, as a rule, electro-positive.

Sulphuric acid is hydrogen sulphate. The hydrogen in it is positive; but zinc is relatively a stronger positive radical and therefore takes its place when zinc is put into the acid.

571. Silver is separated from a solution of silver nitrate by metallic copper, the copper taking the place of the silver in the solution. If the separated silver be filtered out and a piece of lead put into the solution of the copper nitrate, the copper will in turn be separated out by the lead, and lead as well as copper can be displaced in a similar way by either iron or zinc.

572. The Electro-chemical Series.—Berzelius arranged the elements known in his day into a series according to their relative electro-chemical position, beginning with the strongest electro-negative element and ending with the strongest electro-positive element. Each element in the series is positive toward any element preceding it, and negative to any element below it. An abbreviation of it is given here:

Negative end—		*Atomic weight.*
Oxygen II.		16.
Sulphur II, IV, VI.		32.
Nitrogen I, III, V.		14.
Fluorine I.		19.
Chlorine I to VII.	Halogens.	35.45
Bromine I to VII.		80.
Iodine I to VII.		126.85
Phosphorus I, III, V.		31.
Arsenic I, III, V.		75.
Chromium II, IV, VI.		52.
Boron III.		11.
Carbon II, IV.		12.
Antimony III, V.		120.
Silicon IV.		28.4
—HYDROGEN I. +		1.
Gold I, III.		197.3
Platinum II, IV.	Noble	195.
Mercury II.	metals.	200.
Silver I, III.		108.
Copper II.		63.4
Bismuth III, V.		209.
Tin II, IV.		119.
Lead II, IV.		207.
Cobolt II, IV.		59.
Nickel II, IV.		58.7
Iron II, IV, VI.		56.
Zinc II.		65.3
Manganese II, IV, VI.		55.
Aluminum IV.		27.
Magnesium II.		24.3
Calcium II, IV.	Alkaline	40.
Strontium II, IV.	earth	87.6
Barium II, IV.	metals.	137.
Lithium I.		7.
Sodium I, III.	Alkali	23.
Potassium I, III, V.	metals.	39.
Positive end +.		

573 Upon an inspection of the preceding table it will be found that oxygen is the strongest electro-negative element, with sulphur as second; and that potassium is the strongest electro-positive element (of the more common elements) with sodium as second.

Oxygen forms with the negative elements (above hydrogen) acid forming oxides; with hydrogen it forms an absolutely neutral oxide, water; and with the positive elements (below hydrogen) it forms basic oxides. The compounds of the halogens with hydrogen are in several respects like the true acids. The compounds formed by sulphur with the other elements are analogous to those formed with them by oxygen. Oxygen and sulphur together form an oxide which produces (with water) the strongest acid known—sulphuric acid. Oxygen and sulphur are dyads and the halogens are monads. The polyvalent negative elements, which are typically represented by nitrogen and carbon, are remarkable for the great number of compound radicals which they form with oxygen and hydrogen.

Hydrogen and oxygen form water. But no less remarkable is the compound radical (HO) called hydroxyl, formed by one atom of each of these wonderful elements. Hydroxyl is contained in all acids, bases and alcohols.

Arsenic, chromium and antimony (above hydrogen) are of a metallic character, but nevertheless form acids.

Below hydrogen we find first gold and platinum which are very weak positive elements. The polyvalent elements bismuth and tin possess analogies with nitrogen and carbon, respectively, and form acids as well as bases.

At the lower end of the series we have the strongest base-forming metals.

574. The student should study this chapter again *after* he has learned the remaining chapters on chemistry, that he may recognize the fact that there is a self-evident intimate connection between the electro-chemical character of the elements on the one hand and their valence and atomic weights on the other.

But the student must not suppose that he can employ the electro-chemical series as a safe guide in pre-determining the course of chemical reactions, or the relative electro-chemical character of compound radicals. An intelligent advanced student may often find satisfactory explanations of established facts by studying such tables as this; but all students must bear in mind at all times that ascertained facts stand both before and after theories, however attractive and really helpful the theories may be. Facts lead to theories, and theories in turn lead to other facts; but experimental science discovers facts independently of theory, and new theories are evolved which supplement, modify, or even supplant previous theories, while the facts stand. Only the learned and experienced may make, apply, analyze, and unmake theories. Students, however, should learn to understand accepted fundamental theories, and their relations to the facts of experience, as far as they can.

CHAPTER XXVIII.

FIXED COMBINING PROPORTIONS AND THE ATOMIC THEORY.

575. A vast number of chemical compounds have been examined, made, and unmade. Weighed quantities have been decomposed into their constituent elements, and the respective weights of these elements also ascertained and found to account for the whole. The same elements in the same proportions have also been put together again and caused to unite, the product being not only the same compound which had before yielded these elements when it was decomposed, but the weight of the product has been found to be exactly the same as the sum of the weights of the elements. Substances have been composed and decomposed in the same manner, and the factors and products weighed, without dealing with elemental molecules, and the results have been as absolute and invariable. Hence, nothing is lost in any chemical reaction, whether the reaction be synthetical or analytical.

576. Water has been repeatedly decomposed. It has been invariably found to yield by its decomposition two elements, oxygen and hydrogen, and nothing else. Water has also been repeatedly made out of oxygen and hydrogen, and can be made of nothing else. Thus it has been conclusively proven that water is composed of hydrogen and oxygen.

Numerous other substances have been decomposed and composed, many times over, and have been proven, analytically and synthetically, to consist invariably of the same elements. In no case has a different result been reached. Hence, *any given kind of matter always contains the same elements*

577. It has been further demonstrated that water contains its oxygen and hydrogen invariably in the proportion of 88.89 per cent. by weight of the oxygen and 11.11 per cent. by weight of the hydrogen. In other words 100 pounds of water always contains 88.89 pounds of oxygen and 11.11 pounds of hydrogen.

If 88.89 pounds of oxygen and 11.11 pounds of hydrogen be made to unite by chemism, the product is exactly 100 pounds of water. If any more than 88.89 pounds of oxygen be used with 11.11 pounds of hydrogen, all of the excess of oxygen above the 88.89 pounds will remain as still oxygen, but 100 pounds of water will be formed; if less oxygen is used, a corresponding quantity of hydrogen will be left over, and a correspondingly smaller amount of water will be obtained.

Hydrochloric acid is composed of 1 pound of hydrogen and 35.45 pounds of chlorine, making 36.45 pounds of the acid ; and chlorine and hydrogen do not unite in any other proportions.

If you try to combine 2 pounds of hydrogen with 35.45 pounds of chlorine you will have just 1 pound of hydrogen left over, etc.

When calomel is decomposed and its constituent elements weighed it is found that 235.45 pounds of calomel contain 200 pounds of mercury and 35.45 pounds of chlorine.

If you combine 200 pounds of mercury with 35.45 pounds of chlorine, you will get just 235.45 pounds of calomel. But if you combine 200 pounds of mercury with 70.9 pounds of chlorine, you will not get calomel at all ; you will, however, get just 270.9 pounds of corrosive sublimate.

Numerous other substances have been decomposed and produced with the result that the proportions of the component elements have been found to be invariable. In no case have the results been otherwise. Therefore *all chemical compounds contain fixed proportions by weight of their component elements.*

578. But it happens frequently that two elements combine with each other in more than one ratio. In every such case, however, the product is a different substance whenever the proportions of the component elements are different; and the proportions necessary to form any particular substance are invariable.

579. The metal manganese unites with oxygen in five different proportions, as follows:

55 pounds of Manganese unites with 16 pounds of oxygen.
55 " " " " 24 " "
55 " " " " 32 " "
55 " " " " 48 " "
55 " " " " 56 "

If you now divide the pounds of oxygen in each case by the smallest number (16), you get the quotients 1, 1½, 2, 3, and 3½.

Nitrogen unites with oxygen also in five proportions :

14 pounds of nitrogen unites with	8 pounds of oxygen						
14 "	"	"	"	16	"	"
14 "	"	"	"	24	"	"
14 "	"	"	"	32	"	"
14 "	"	"	"	40	"	"

If you again divide the number of pounds of oxygen by the smallest number (8), you will get 1, 2, 3, 4 and 5.

Chlorine forms four oxides :

709 pounds of chlorine unites with 160 pounds of oxygen.						
709 "	"	"	"	480	"	"
709 "	"	'	"	800	"	"
709 "	"	"	"	1,120	"	"

Divide the pounds of oxygen as before the quotients are 1, 3, 5 and 7.

Three chlorides of manganese are known:

550 pounds of manganese unites with	709	pounds of chlorine.			
550 "	"	"	"	1,063.5	"
550 "	"	"	'	1,418	"

Divide the pounds of chlorine as before the oxygen and you get the numbers 1, 1½ and 2.

Compare these tables with each other and you will further find that 550 pounds of manganese unites with 160 pounds of oxygen, but with 709 pounds of chlorine; that 709 pounds of chlorine also unites with 160 pounds of oxygen.

580. The simplicity of these proportions is found to extend to all chemical compounds. How is it to be accounted for?

If it be assumed that the elements are not divisible without limit, but that each element consists of indivisible particles having a fixed weight, that assumption will explain it all satisfactorily No other theory has ever been proposed which does account for the fixed combining proportions observed in all chemical compounds.

581. It has been stated that it takes 8,000,000,000 molecules of water to make a particle of water of sufficient size to be seen by the aid of one of the best modern microscopes.

Sir William Thomson says: "If we conceive a sphere of water of the size of a pea to be magnified to the size of the earth, each molecule to be magnified to the same extent, the magnified structure would be coarser grained than a heap of small lead shot, but less coarse-grained than a heap of cricket-balls."

It has been estimated that the mean diameter of molecules is so small that if 500,000 of them were placed in a row, the row would be only $\frac{1}{10000}$ inch in length. It has also been said that the molecules of hydrogen are about $\frac{1}{5000000}$ of an inch apart from each other. Each molecule of hydrogen contains two atoms.

But these dimensions are beyond intelligent comprehension. Atoms are so small that their diameter and absolute weight can not be determined, and for purposes of argument we may as well assume that they weigh pounds as that they weigh an infinitesimal fraction of a milligram. The *relative* weights of atoms are believed to be correctly determined.

582. If we assume, then, for argument's sake, that an atom of hydrogen weighs 1 pound, an atom of oxygen 16 pounds, nitrogen 14 pounds, chlorine 35.45 pounds, manganese 55 pounds, and mercury 200 pounds, and that these atoms are indivisible—then the definite combining proportions observed in the examples given in paragraphs 577 and 579 will not only become intelligible, but they could not be otherwise than fixed.

Peroxide of hydrogen will be obtained when 1 pound of hydrogen forms molecules with 16 pounds of oxygen; but 2 pounds of hydrogen forms water with 16 pounds of oxygen; 16 pounds of oxygen unites with 14 pounds of nitrogen to form nitrogen dioxide; 14 pounds of nitrogen unites with 3 pounds (3x1) of hydrogen to form ammonia; 14 pounds of nitrogen unites with 106.35 pounds (3x35.45) of chlorine forming nitrogen chloride; 3 pounds of hydrogen and 106.35 pounds of chlorine unite to form hydrochloric acid; 106.35 pounds of chlorine united with 55 pounds of manganese will form manganic chloride; 55 pounds of manganese unites with 16 pounds of oxygen forming manganous oxide; 16 pounds of oxygen unites with 200 pounds of mercury to form mercuric oxide; and 200 pounds of mercury unites with 35.45 pounds chlorine to form calomel, or with twice that amount of chlorine to form corrosive sublimate.

583. The Atomic Theory.—On account, then, of the fixed combining proportions (577 and 579) it is assumed that *all matter is divisible into small particles called atoms which are themselves indivisible*

having fixed weights (580 and 582). This theory was proposed by Dalton.

584. Atomic Weights.—The smallest weight of any element which can enter into the formation of a compound is its atomic weight. Atomic weights are expressed in hydrogen units; the relative weight of any atom as compared to the weight of the atom of hydrogen (H = 1), therefore expresses its atomic weight.

Practically the smallest relative quantity by weight which has been found in the various compounds of an element is assumed to represent its atomic weight. This is the quantity by weight which unites with or can take the place of one atom of hydrogen.

Whether or not the numbers called atomic weights actually represent the relative weights of atoms, they serve to express truthfully the definite and multiple proportions in accordance with which all compounds are formed.

The molecular weight being known and also the number of atoms in the molecule, the atomic weight is found by dividing the molecular weight by the atomicity of the molecule.

585. Dalton's Law of Multiple Proportions.—*Whenever any two elements combine in more than one proportion, the several compounds formed by these elements contain simple multiples of the atomic weights of both constituents.*

Thus if A and B unite in several different proportions, their atoms unite in the numerical ratios of 1 to 1, or 1 to 2, or 1 to 3, or 1 to 4, or 1 to 5, or 1 to 6, or 2 to 2, or 2 to 3, or 2 to 4, or 2 to 5, or 2 to 6, or 2 to 7, or 3 to 4, or 3 to 5, or 3 to 7, or some other simple ratio.

586. Dulong and Petit, in 1819, proposed the law that *all atoms have the same capacity for heat.*

In other words, it requires exactly the same amount of heat to raise the temperature of any atom one degree, without reference to its kind.

Their proposition was based upon a series of investigations by which it became evident that a simple proportion exists between the specific heats and the *atomic weights* of the *elements.* These were found to be inversely proportional.

587. Specific heat is the relative quantity of heat necessary to raise the temperature of one weight unit of any substance one thermal degree.

Specific heat is expressed in units of the specific heat of water, which is taken as the thermal standard. Thus the quantity of heat necessary to raise one weight unit of water one degree is the specific heat of water, and being chosen as the standard of comparison it is $= 1$.

But mercury requires only $\frac{3190}{100000}$ as much heat as water does to raise the same quantity of it one thermal degree, and, therefore, the specific heat of mercury is 0.0319.

588. Investigations by Neumann and Regnault, in 1831, proved that the specific heats of *compounds* are inversely proportional to their *molecular weights*.

589. Thus, the specific heat of elements is inversely as their atomic weights, and the specific heat of compounds inversely as their molecular weights.

After further investigations by Regnault and others, with a great variety of compounds, it was concluded that *all atoms, free or combined, have the same capacity for heat.*

These valuable discoveries afforded a new means of finding or verifying atomic and molecular weights.

590. Deduction of Atomic Weight from Specific Heat.— The atomic weights of elements may be verified by examining the specific heats of their solid compounds.

When the specific heat of any elementary body is multiplied by its atomic weight the product is a constant number. Owing to the unavoidable liabilities to error in such difficult determinations, the specific heats and the atomic weights found by the best methods known are not absolutely correct, and hence the product of the atomic weight by the specific heat varies somewhat, but the mean is 6.40. Whenever, therefore, the product varies considerably from that mean, one or both factors are assumed to be wrong; and should the product be only one-half of 6.40, or should it be twice 6.40, the inference would be that the atomic weight used is double or one-half of the actual.

591. Atomic Heat.—The number obtained by multiplying the specific heat of any element by its atomic weight is called its *atomic heat.*

As already stated, it is near 6.4. All elements are assumed to have the same atomic heat under certain conditions.

[The molecular heat divided by the number of atoms contained in the molecule will also give the atomic heat.]

592. The atomic heat of any element (6.4) divided by its specific heat will give its atomic weight; and the atomic heat divided by the atomic weight will give the specific heat. The specific heat multiplied by the atomic weight gives the atomic heat.

593. **Molecular Weight.**—The molecular weight of any substance, or the weight of its molecule, is the sum of the weights of its constituent atoms. It is, therefore, found by adding these together.

594. **Molecular Heat.**—The number obtained by multiplying the specific heat of any compound by its molecular weight is called its *molecular heat*. It is the sum of the atomic heats of the atoms it contains.

The molecular heat of any compound divided by the number of atoms contained in the molecule will give as a quotient the mean of the atomic heats of the elements, which, with rare exceptions, is about 6.4 (590)

595. The number of atoms contained in any molecule may, therefore, be readily ascertained if its specific heat and molecular weight are known; for if the molecular heat is divided by 6.4 (the atomic heat) the quotient is the number of atoms in the molecule. It is of course also found by dividing the molecular weight by the atomic weight.

596. The specific heat of a substance may be found by dividing the molecular heat by the molecular weight.

597. **Combination by volume in simple proportions.** Gay Lussac found that gases always combine in simple proportions by volume, and also that the volume of the product in the gaseous state bears a simple relation to the volumes of the constituents.

One volume of hydrogen unites with one volume of chlorine, producing two volumes of hydrochloric acid; two volumes of hydrogen unite with one volume of oxygen, producing two volumes of water-vapor; three volumes of hydrogen and one volume of nitrogen unite to form two volumes gaseous ammonia; etc.

As elements combine in fixed proportions by weight, and, in the gaseous state, also in fixed proportions by volumes, it follows that the weights of equal volumes of all gases bear the same relation to each other as do the combining weights of the

elements. and if the atomic theory is correct *the number of atoms contained in a given volume of any gas bears a simple relation to the number of atoms contained in the same volume of any other gas.*

598. In paragraph 582 it was shown that the relative combining weights, or atomic weights, of the four most important gaseous elements are as follows:

Hydrogen.................................. 1
Nitrogen........................... 14
Oxygen......................................16
Chlorine 35.45

When the weights of equal volumes of these gases are compared it is found that the above figures, representing their atomic weights, also express the relative weights of equal volumes. Thus one quart of nitrogen weighs 14 times as much as a quart of hydrogen, a quart of oxygen weighs 16 times as much as a quart of hydrogen, and a quart of chlorine gas 35.45 times as much as a quart of hydrogen.

As the specific weight of any kind of matter in a gaseous state, called its *vapor density*, is expressed in hydrogen units, the specific weight of hydrogen being taken as 1, we find that the vapor densities of hydrogen, nitrogen, oxygen and chlorine are exactly expressed by their atomic weights.

599. Avogadro's Law.—The simple relations between the atomic weights and vapor densities of the elements of course appear also when the molecular weights are compared with the vapor densities, for the molecules of the elements are made up of a small number of atoms and the molecular weight is the sum of the weights of the atoms. Thus:

ELEMENT.	Vapor Density.	Atomic Weight.	Molecular Weight.
Hydrogen.................	1	1	2
Nitrogen...............	14	14	28
Oxygen	16	16	32
Chlorine...	35.45	35.45	70.90

If comparisons be made of the weights and vapor densities of compound molecules, the same simple relations are found:

COMPOUND.	Vapor Density.	Molecular Weight.
Water..........	9	18
Hydrochloric Acid........	18.23	36.4,
Sulphur Dioxide......................	32	64
Ammonia.....	8.5	17
Marsh-gas	8	16
Chloroform...	59.75	119.5

Avogadro accordingly proposed the hypothesis: *Equal volumes of all gases contain the same number of molecules.*

600. If the molecular weight of any substance be divided by the vapor density (expressed in hydrogen units), the quotient should always be 2. The vapor density multiplied by 2 should give the molecular weight; and the molecular weight divided by 2 should give the vapor density.

[But Crafts and Meyer reduced the vapor density of iodine by heating until it was but one-half of the normal, or only one-fourth of the accepted molecular weight. That makes it appear as if iodine was then in an atomic condition.]

601. It is easily shown that the molecule of hydrogen contains at least two atoms, and for good reasons it is assumed that the number does not exceed two.

Hydrogen having been chosen as the unit of atomic weight, its molecular weight is 2, and if Avogadro's hypothesis is applied it is found that the molecular weight of any substance coincides with its vapor density multiplied by 2.

It follows that the vapor density of any substance is expressed by one-half its molecular weight.

602. As it follows from the atomic hypothesis that the number of atoms contained in any elemental molecule is obtained by dividing the molecular weight by the atomic weight, therefore :—The atomic weight of all elements having diatomic molecules (2 atoms in each molecule) coincides with the vapor density; if the molecule contain but one atom the atomic weight is equal to twice the vapor density; in elements with triatomic molecules (3 atoms in each molecule) the atomic weight is equal to two-thirds of the vapor density; in elements with tetratomic molecules (4 atoms in each molecule) the atomic weight is equal

to one-half of the vapor density; and in elements with hexa-
tomic molecules (6 atoms in each molecule) the atomic weight
is equal to one-third of the vapor density.

603. If it be assumed that one measure of hydrogen contains 1,000 mole-
cules of hydrogen, one measure of oxygen contains the same number (599).
Two measures of hydrogen, containing 2,000 molecules, would contain 4,000
hydrogen atoms, and one measure of oxygen would contain 2,000 oxygen
atoms, for the molecules of hydrogen and oxygen have both been found to be
diatomic. The total number of atoms, then, contained in the two measures of
hydrogen and one measure of oxygen would be 6,000. When combined
they form two measures of water vapor. According to Avogadro's law these
two measures must contain the same number of molecules as the two measures
of hydrogen, or 2,000. Now, as these 2,000 molecules of water were formed
out of 4 000 atoms of hydrogen and 2,000 atoms of oxygen, there must be 2
atoms of hydrogen and 1 atom of oxygen in each water molecule, which is
exactly what the molecule of water has been shown by other means to contain.

The fact that 2 measures of hydrogen and 1 measure of oxygen form only
2 measures of water vapor, is accounted for by the fact that the water molecules
contain 3 atoms each while the molecules of hydrogen and oxygen contain
only 2 atoms each.

1 volume of Hydrogen and 1 volume of Chlorine produce 2 volumes of
Hydrochloric Acid gas.

2 volumes of Hydrogen and 1 volume of Oxygen produce 2 volumes of
Water vapor.

3 volumes of Hydrogen and 1 volume of Nitrogen produce 2 volumes of
gaseous Ammonia.

Hydrochloric acid is diatomic, and, therefore, requires only two volumes of
diatomic elements to produce the same number of molecules.

The molecule of water is triatomic, and, therefore, requires three volumes
of diatomic elements to produce the same number of molecules.

Ammonia is tetratomic, and, therefore, requires four volumes of diatomic
elements to produce the same number of molecules.

604. The atomic weights used in this book are given in the
table on the opposite page. The newly-discovered elements
Argon and Helium, are not included in it.

Table of Atomic Weights. (H=1.)

The names of elements occurring in pharmacopœial, medicinal chemicals are printed in heavy faced type.

Name.	Symbol	Atomic Weight.	Name.	Symbol	Atomic Weight.
Aluminum	**Al**	**27.**	Molybdenum	Mo	96.
Antimony	**Sb**	**120.**	Nickel	Ni	58.6
Arsenic	**As**	**75.**	**Nitrogen**	**N**	**14.**
Barium	**Ba**	**137.**	Osmium	Os	190.3
Bismuth	**Bi**	**209.**	**Oxygen**	**0**	**16.**
Boron	**B**	**11.**	Palladium	Pd	106.4
Bromine	**Br**	**79.8**	**Phosphorus**	**P**	**31.**
Cadmium	Cd	111.5	Platinum	Pt	194.3
Cæsium	Cs	132.7	**Potassium**	**K**	**39.**
Calcium	**Ca**	**40.**	Rhodium	Rh	103.5
Carbon	**C**	**12.**	Rubidium	Rb	85.
Cerium	**Ce**	**140.**	Ruthenium	Ru	101.4
Chlorine	**Cl**	**35.4**	Samarium	Sm	150.
Chromium	**Cr**	**52.**	Scandium	Sc	44.
Cobalt	Co	58.6	Selenium	Se	79.
Columbium[1]	Cb	93.7	**Silicon**	**Si**	**28.3**
Copper	**Cu**	**63.2**	**Silver**	**Ag**	**107.7**
Didymium[2]	Di	142.	**Sodium**	**Na**	**23.**
Erbium	Er	166.	Strontium	Sr	87.3
Fluorine	F	19.	**Sulphur**	**S**	**32.**
Gallium	Ga	70.	Tantalum	Ta	182.
Germanium	Ge	72.3	Tellurium	Te	125.
Glucinum[3]	Gl	9.	Terbium	Tb	159.
Gold	**Au**	**196.7**	Thallium	Tl	203.7
Hydrogen[4]	**H**	**1.**	Thorium	Th	232.
Indium	In	113.6	Tin	Sn	119.
Iodine	**I**	**126.5**	Titanium	Ti	48.
Iridium	Ir	192.5	Tungsten	W	183.6
Iron	**Fe**	**56.**	Uranium	U	239.
Lanthanum	La	137.9	Vanadium	V	51.
Lead	**Pb**	**206.4**	Ytterbium	Yb	172.6
Lithium	**Li**	**7.**	Yttrium	Yt	89.
Magnesium	**Mg**	**24.3**	**Zinc**	**Zn**	**65.1**
Manganese	**Mn**	**55.**	Zirconium	Zr	90.4
Mercury	**Hg**	**200.**			

1) Has priority over Niobium. 2) Now split into Neo- and Praseo-Didymium.
3) Has priority over Beryllium. 4) Standard, or basis of the system.

CHAPTER XXIX.

VALENCE.

605. We have said that atoms unite with each other to form molecules. All atoms of the same kind have the same chemical saturating power ; that is, the *quantity* of the chemism of any one atom is exactly the same as the quantity of the chemism of any other atom of the same kind. One atom has the same combining value as another atom of the same kind.

It is also found that one kind of atoms may have the same combining value or saturating power as atoms of a certain other kind. Thus, chlorine atoms and hydrogen atoms have the same combining value, so that one atom of chlorine combines with one atom of hydrogen, both atoms being thereby saturated, so that not more than one atom of each kind can unite, and so that no other atom of any kind can unite with one atom of chlorine and one of hydrogen tied together. This equality of combining power, or chemical saturating capacity, or atomic value, or combining value, is also shown by the atoms of potassium and chlorine, by calcium and oxygen, silver and iodine, zinc and sulphur, boron and nitrogen, etc. In all these cases one atom of one kind unites with one atom of the other kind forming a molecule incapable of combining with any other atom or radical. The chemism of the atoms of the molecule is, therefore, exhausted, saturated, satisfied, or neutralized.

606. But an atom of chlorine has only one-half the value of an atom of calcium, for two atoms of chlorine are always required to saturate (or form a molecule with) one atom of calcium. One atom of oxygen has twice as great combining power as an atom of potassium, and twice the value also of an atom of hydrogen, for one atom of oxygen will satisfy at once one atom of each of potassium and hydrogen. One atom of nitrogen demands three atoms of hydrogen—no more, and no less.

If we use the letter H to represent an atom of hydrogen, O to represent an atom of oxygen, N to represent an atom of nitrogen, C to represent an atom of carbon, and append numerals

to represent any number of atoms exceeding one, we shall be able to write the molecular formulas (630) of hydrochloric acid, water, ammonia, and marsh-gas.

HCl	H_2O	H_3N	H_4C
Hydrochloric Acid	Water	Ammonia	Marsh-gas

These formulas show that if the combining value of the hydrogen atom is expressed by 1, then the value of the oxygen atom is 2, that of the nitrogen atom is 3, and that of the carbon atom 4.

607.   Radicals (519) unite with each other in accordance with their relative combining or saturating power, which is called their *valence*.   One or two atoms of one kind may, apparently, be capable of saturating one or two, three, four, five, six or seven atoms of another kind; or two atoms of one kind may saturate three or five atoms of another kind.   The same is true of compound radicals.

Thus, one atom of hydrogen binds one other atom of hydrogen; but one atom of oxygen binds two atoms of hydrogen; one atom of nitrogen saturates three atoms of hydrogen; one atom of carbon satisfies four of hydrogen; and, while the atoms of chlorine and hydrogen are of equal value (as one atom of either binds one atom of the other), an atom of tantalum is of equal value with five atoms of chlorine; one atom of tungsten satisfies six atoms of chlorine; and the atomic value of chlorine in one of its compounds with oxygen appears as if it were seven times that of hydrogen.

608.   Valence is also called " atomic value," "quantivalence," "equivalence " [and sometimes also " atomicity "*].

609.   Valence is expressed in hydrogen units.   Hydrogen has been adopted as the standard of comparison for this purpose because the atom of hydrogen has a smaller valence than any other atom except those having the same value as itself.

Therefore the valence of a radical may also be said to be represented by the number of atoms of hydrogen which it satisfies, or equals in combining power, or for which it can be exchanged.

Hydrogen, being the unit, has a valence of one; any other radical uniting with, or capable of taking the place of, two atoms

* The term atomicity has also been used to express the number of atoms contained in an elemental molecule (471).

of hydrogen has the valence 2; a radical which takes the place of, or satisfies, three atoms of hydrogen, has a valence expressed by the number 3, etc.

610. Many elements and radicals do not unite with hydrogen; but they do unite with other radicals whose valence has been ascertained, and the valence of all radicals must be determined, not with reference to their hydrogen compounds merely, but to their compounds generally, and especially with regard to their most important and best known compounds, whatever these may be. Thus, not only hydrogen compounds, but also oxides, chlorides and other molecules must be studied in order to correctly determine the valence of any element or compound radical.

611. Artiads and Perissads.—Radicals whose valence is expressed by an even number, as 2, 4, or 6, are called *artiads;* while radicals of an uneven valence, as 1, 3, 5, or 7, are called *perissads.*

612. The artiads are more numerous than the perissads. Hydrogen, and all other radicals having the same valence, are called *monads*, and are *univalent;* radicals which unite with or replace two hydrogen or chlorine atoms are called *dyads* and are *bivalent;* those that satisfy or replace three hydrogen or chlorine atoms are called *triads* and are *trivalent;* those equal in value to four hydrogen or chlorine atoms are *tetrads* and *quadrivalent;* radicals whose atomic value is five are called *pentads*, and they are *quinquivalent;* those whose valence is six are *hexads* and *sexivalent;* and radicals with an atomic value of seven are *heptads* and *septivalent.*

613. The valence of chlorine is 1, because 1 atom of chlorine will unite with and saturate 1 atom of hydrogen, or will replace it. Chlorine is, accordingly, like hydrogen, a *monad* and *univalent.* Iodine, bromine and fluorine are also monads for the same reasons. Potassium, sodium, lithium and silver are monads, too, because 1 atom of any one of them will take the place of 1 atom of hydrogen, and because either of them will unite with and saturate 1 atom of chlorine, iodine or bromine.

Oxygen is a *dyad*, for 1 atom of it saturates 2 atoms of hydrogen.

Negative nitrogen is a *triad*, because 1 atom of it will satisfy 3 atoms of hydrogen.

Carbon has the valence of a tetrad, for 1 atom of it saturates 4 atoms of hydrogen.

For similar reasons other radicals are pentads, hexads or heptads.

No radical has a higher valence than eight, and the two highest valences (seven and eight) are comparatively rare.

614. Radicals of a higher atomic value than that of hydrogen, or radicals having more than one free bond, are called *polyvalent* radicals. Thus all atoms and compound radicals except monads are polyvalent. In comparing the structures of compound radicals and of binary and ternary molecules with each other, this term is convenient.

Radicals having the same valence may be called *equivalent.* Thus potassium and hydrogen are equivalent atoms, both being univalent; zinc and oxygen are equivalent, for both are dyads.

615. Bonds.—The valence units or affinities of atoms are sometimes, for convenience, called *bonds.* Thus, a monad or univalent atom has one bond; a dyad or bivalent atom has two bonds; a triad or trivalent atom has three bonds; a tetrad or quadrivalent atom has four bonds; a pentad or quinquivalent atom has five bonds; a hexad or sexivalent atom has six bonds; and a heptad or septivalent atom has seven bonds.

Any atom which saturates or replaces	Has the following number of bonds.	Is called a	And is
1 atom of hydrogen or chlorine.........	1 bond,	Monad,	Univalent.
2 atoms " "	2 bonds,	Dyad,	Bivalent.
3 " " "	3 "	Triad,	Trivalent.
4 " " "	4 "	Tetrad,	Quadrivalent.
5 " " "	5 "	Pentad,	Quinquivalent.
6 " " "	6 "	Hexad,	Sexivalent.
7 " " "	7 "	Heptad,	Septivalent.

616. We might liken the atoms to coins, each having a definite value corresponding with the combining power. Monads may be likened to one-cent coins, dyads to two-cent coins, triads to three-cent coins, tetrads to four-cent coins, etc. As a two-cent coin is worth two one-cent coins, so a dyad atom is equal to two monad atoms; as it takes three one-cent pieces, or one two-cent and one one-cent piece to equal one three-cent piece, so does it take three

monad atoms, or one dyad and one monad to equal one triad; and as three two cent pieces have the same value as two three-cent pieces, so are two triad atoms equal to three dyad atoms, etc.

617.   Variable Valence.—But the valence of elements is not always constant.   Indeed very few of the elements seem to have a constant valence.   Hydrogen and oxygen, which are the most remarkable and important of all elements, are assumed to have a constant valence.

It was shown that (579) nitrogen and manganese have each five different oxides, or compounds formed by them with oxygen.

618.   Among the examples of variable valence we find:

Nitrogen appears to be trivalent in forming ammonia because in that molecule 1 atom of nitrogen is united to 3 atoms of hydrogen ; while in a molecule of ammonium chloride 1 atom of nitrogen is united to 4 atoms of hydrogen, and 1 atom of chlorine besides, thus *appearing to have* in this case a total valence of 5.

Phosphorus unites with 3 atoms of hydrogen to form phosphine, and is then apparently a triad ; but when 2 atoms of phosphorus unite with 5 of oxygen the phosphorus *would seem to be* a pentad, for each oxygen atom has a valence of 2.

Sulphur unites with two atoms of hydrogen and is then bivalent; but one atom of sulphur also unites with two atoms of oxygen and then it *seems* to be a tetrad ; and in the sulphuric acid molecule *it appears as if* it were a hexad.

619.   In some notable instances it appears as if variable valence depends upon the electro-chemical polarity.

Thus *sulphur* is positive toward oxygen, but negative toward all other elements, and you will find that negative sulphur is always a dyad, while sulphur united to oxygen (positive sulphur) presents the higher valences of four or six.

Nitrogen is negative toward hydrogen but positive toward oxygen, so that we have negative nitrogen in ammonia but positive nitrogen in nitric anhydride (569). The negative nitrogen is a triad, but nitrogen united to oxygen may apparently have a valence of either one, three, or five.   In nitric acid the nitrogen seems to be a pentad.   And if a molecule of ammonia be brought in contact with a molecule of hydrochloric acid, the nitrogen of the ammonia not only changes its valence from that of a triad to that of a pentad, but it also changes its electro-chemical polarity from negative to positive.

Phosphorus, like the nitrogen, is negative in its union with hydrogen, and then always trivalent, but it is positive in the formation of its oxides and compound radicals with oxygen and then may have, apparently, one, three or five valence units.

Chlorine is always univalent when it acts as an electro-negative radical, as in all chlorides, but the molecular formulas of its oxides and acids indicate higher valences for the positive chlorine.

[In certain cases it has been observed that the valence of an element may be changed by heat.]

620. It has been found that the valence of an atom never varies by a single valence unit, but always by two units, or by a multiple of two units.

Thus an atom which exhibits a valence of 1 in one of its compounds, may in other compounds show a valence of 3, or 5, or 7, but never 2, 4, or 6; and another atom exhibiting in one case a valence of 2 may in other cases show a valence of 4 or 6, but never 1, 3, 5 or 7.

621. It has been sought to explain this fact on the assumption that the *true valence* of any atom is its highest apparent valence, and that this *maximum valence* may be diminished by the mutual saturation of pairs of its bonds (615).

To illustrate this partial *self-saturation* of atoms we will picture a series of atoms with bonds representing their respective valences:

MONAD.   DYAD.   TRIAD.   TETRAD.   PENTAD.   HEXAD.   HEPTAD.

Or, they may be represented as follows, since the direction in which the bonds are extended is, of course, immaterial, and neither of these pictures can be likenesses of actual atoms:

The mutual saturation of pairs of bonds may be represented as follows:

HEPTADS CHANGED
TO PENTADS.

HEPTADS CHANGED
TO TRIADS.

PENTADS CHANGED TO
TRIADS.

TRIADS CHANGED TO
MONADS.
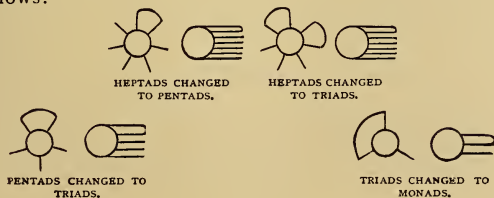
OCTAD CHANGED TO TETRAD, AND
HEXAD TO DYAD.
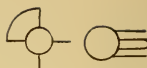
TETRADS CHANGED TO
DYADS.

Thus, if this assumption be accepted, a heptad can change to a pentad by the mutual saturation of two of its bonds, or it can become a triad by the mutual saturation of two pairs of its bonds, or it may even become a monad by the mutual saturation of six of its bonds in pairs. A hexad may become a dyad by the pairing of four bonds, or a tetrad if only two of its bonds be paired off.

But an artiad can never become a perissad, nor can a perissad change to an artiad.

In other words, no atom can at one time present an even number of bonds and at another time an odd number.

622. In view of the variable valence of atoms it is difficult to classify the elements according to their valence, beyond a separation of the artiads from the perissads.

The following table is arranged according to *the maximum valences* of the respective elements. The comparatively rare and unimportant elements are omitted from this table, and in all cases where the *ruling valence* differs from its maximum valence, the ruling valence of the element, or that valence which it plainly exhibits in its most important and stable compounds, is shown by Roman numerals in brackets :—

Table of Atomic Values of the Elements (according to the maximum valence):

Monads (univalent, or with one bond):

Hydrogen.
Negative Chlorine.
"   Bromine.
"   Iodine.

Dyads (bivalent or with 2 bonds)

Oxygen.
Negative Sulphur.
Magnesium.
Zinc.

Cadmium.
Mercury.
Copper.

Triads (trivalent, or with 3 bonds):

Boron.	Sodium (I).
Negative Nitrogen.	Silver (I).
Negative Phosphorus.	Gold.
" Arsenic.	

Tetrads (quadrivalent, or with 4 bonds):

Carbon.	Calcium (II).
Silicon.	Strontium (II).
Tin.	Barium (II).
————	————
Aluminum.	
Platinum.	Lead (II).

Pentads (quinquivalent, or with 5 bonds):

Positive Nitrogen (also I and III).
    "   Phosphorus (III).
    "   Arsenic (III).   Potassium (I).
    "   Antimony (III).
    "   Bismuth (III).

Hexads (sexivalent, or with 6 bonds):

Positive Sulphur (also IV).
Chromium (II).
Manganese (II).
Iron (II and IV).

623. The complexity of molecules depends mainly upon the relative valence of their component atoms. This will be easily understood when we remember that all the valence units in the molecule must be mutually tied, combined, satisfied, or saturated.

624. Valence has no relation to the energy of chemism called chemical affinity.

Chlorine, though a monad, has a powerful chemical affinity, whereas carbon which is quadrivalent is entirely inactive at ordinary temperatures. The trivalent element, phosphorus, on the other hand, is more energetic in its

chemical combining power than either quadrivalent carbon, trivalent nitrogen, bivalent sulphur, or univalent hydrogen (521).

625. All compound radicals have an invariable valence; and variable valence seems to occur only in what is called *inorganic chemistry*.

626. As long as the causes of variable valence remain unknown, the laws of chemical combination must continue to appear less simple then they probably are in reality. In the meantime we must remember that the valence of many elements is variable; that the maximum valence of an atom may not be its common valence, nor its valence in its most important, or its most stable, compounds.

But in all cases where we know the radicals entering into a molecule, and also their respective valences, we can readily construct their molecular formulas. Even in cases where elemental radicals are concerned it is practicable to base the molecular formulas of most of the important compounds upon valence, and to learn to write formulas accordingly.

CHAPTER XXX.

CHEMICAL NOTATION.

627. Chemical Notation is the system of representing atoms and molecules by means of symbols and formulas.

Atoms are represented by symbols ; molecules by formulas.

628. Symbols are abbreviations or signs consisting of letters. In many cases the symbol consists of but one letter, and in all such cases that letter is the initial of the Latinic name of the element. In cases where the Latinic names of two or more elements begin with the same letter, an additional letter from that name is added to make the necessary distinction. The additional letter thus used may be the second letter in the name, or some other letter.

The symbols, therefore are abbreviations of the Latinic names of the elements, and consist of but one or two letters. In

symbols consisting of two letters only the first is a capital letter.

No two atoms are represented by the same symbol.

Thus Boron is represented by B, Carbon by C, Hydrogen by H, Nitrogen by N, Oxygen by O, Potassium by K (the Latinic name of it is Kalium), etc.

As B is used for Boron, Ba is the symbol for Barium, Bi for Bismuth, and Br for Bromine. C being the symbol for Carbon, Ca is used for Calcium, Cl for Chlorine, and Cu (from Cuprum) for Copper. Having given the symbol N to Nitrogen, it was necessary to make the symbol for Nickel Ni, and for Sodium Na (from Natrium).

629. To represent one atom the symbol is sufficient alone. To represent an elemental molecule the symbol is accompanied by a small Arabic numeral to the right of the symbol, the number expressing the number of atoms contained in the molecule, thus:—H_2, K_2, O_2, P_4, Cl_2, etc.

630. **Formulas** are combinations of symbols with numerals to express the kinds and numbers of atoms entering into the molecules of matter.

The formulas for elemental molecules, as shown in the preceding paragraph, are simple because elemental molecules each contain but one kind of atoms.

The formulas for compound molecules are constructed out of at least as many symbols as there are different kinds of atoms in the molecule which is to be represented, and after each symbol is placed the numeral expressing the numbers of atoms if more than one.

The positive radical is always placed before the negative radical.

As the molecule of potassium iodide contains one atom of the positive potassium and one of the negative iodine, its molecular formula must be written KI; but the molecule of water is composed of two atoms of hydrogen and one atom of oxygen, and its formula must, therefore, be H_2O; a molecule of hydrochloric acid is HCl, for it contains one atom of each of hydrogen and chlorine, and the molecular formula for hard soap (sodium oleate) is $NaC_{18}H_{33}O_2$, because it contains one atom of sodium, eighteen atoms of carbon, thirty-three atoms of hydrogen and two atoms of oxygen.

631. Single molecules are represented by the respective

molecular formulas. Thus HCl represents not only hydrochlo-
ric acid, but also one single molecule of hydrochloric acid.
When two or more molecules are to be written, a large Arabic
numeral is placed in front (or to the left) of the molecule.

Thus three molecules of hydrochloric acid must be written 3HCl; two
molecules of water must be written $2H_2O$; and 5KI stands for five molecules
of potassium iodide; $4NH_3$ represents four molecules of ammonia, and
$2NaC_{18}H_{33}O_2$ means two molecules of sodium oleate.

632. When a group of atoms or a compound radical is to
be multiplied, the symbols of the atoms or the formula of the
radical must be enclosed in brackets and the numeral placed
outside below and to the right.

Thus, $Ca(OH)_2$ represents calcium hydrate, which contains one atom of
calcium, two atoms of oxygen and two atoms of hydrogen; but as each
hydrogen atom is united directly to one of the oxygen atoms and the com-
pound thus contains two groups of the radical HO, and as this radical is
united to the calcium atom by means of bonds from the oxygen, the formula
is correctly written $Ca(OH)_2$. The formula $Pb(NO_3)_2$ represents lead nitrate,
which contains the group NO_3 twice.

[Entire molecules are occasionally multiplied in the same manner—that
is, by enclosing the molecular formula in brackets and placing the multipli-
cator or numeral outside, below, to the right.]

633. A large numeral placed in front of any formula applies
to all that follows it up to the first period; except that if that
numeral is placed directly in front of brackets enclosing a form-
ula the number multiplies all that is contained within those
brackets.

In $2K_2CO_3$ the first figure 2 applies to all that follows it as a whole.

In $2K_2CO_3.3H_2O$ the first figure 2 applies to K_2CO_3, and to nothing
more, and the large figure 3 applies to the formula H_2O. But in $3(2K_2CO_3.$
$3H_2O)$, and in $(2K_2CO_3.\ 3H_2O)_3$ the figure 3 outside the brackets applies to all
within.

In $4MgCO_3.Mg(OH)_2.5H_2O$ the figure 4 applies only to $MgCO_3$; the
inferior figure 2 in $Mg(OH)_2$ applies only to the group OH, and the figure 5
applies to H_2O.

In $3Pb(C_2H_3O_2)_2$ the figure 3 in front applies to the entire formula which
follows, viz., to $Pb(C_2H_3O_2)_2$.

In $6(NaC_2H_3O_2.\ 3H_2O)$ the figure 6 applies to all that is contained within
the brackets.

In $2(Fe_2(C_6H_5O_7)_2.\ 6H_2O)$ the large figure 2 in front applies to all that

follows, while the inferior figure $_2$ in $(C_6H_5O_7)_2$ applies only to the group $C_6H_5O_7$, and the large figure 6 only to H_2O.

In $Fe_4(P_2O_7)_3 \cdot 4(Na_3C_6H_5O_7) \cdot 8H_2O$. we see that there are four atoms of iron, 3 groups of the radical P_2O_7, then 4 times $Na_3C_6H_5O_7$, and 8 molecules of water.

Thus it will be seen that in representing the formulas of some complex molecules it is necessary to use both large and inferior numerals, more than one pair of brackets, and brackets within brackets.

634. The valence of elements is indicated by Roman numerals at the top and a little to the right of the symbol, thus:—H^i means univalent hydrogen; O^{ii} means bivalent oxygen; N^{iii} means trivalent nitrogen; N^v, quinquivalent nitrogen; C^{iv} means quadrivalent carbon; S^{ii}, bivalent sulphur; S^{iv}, quadrivalent sulphur; S^{vi}, sexivalent sulphur; Ta^v, quinquivalent tantalum; and W^{vi}, sexivalent tungsten.

635. Chemical Equations.—Chemical decompositions and reactions are conveniently and clearly represented by the numbers and formulas of the molecules which are decomposed in the reaction and the numbers and formulas of the molecules resulting by it. This is done in the form of an equation.

The molecules which take part in the change are placed on the left of the sign $=$, and the molecules of the product or products on the right.

Thus:——

$Fe_2 + 2I_2 = 2FeI_2$;

$2Na_2HPO_4 - H_2O = Na_4P_2O_7$;

$CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl$; and

$Hg_2(NO_3)_2 \cdot 2H_2O = 2HgO + N_2O_4 + 2H_2O$.
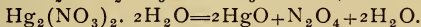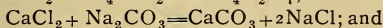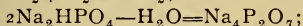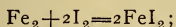
636. The number of molecules taking part in a chemical reaction varies according to the respective valences of the radicals concerned, or the atomic rearrangement produced.

In many cases only one molecule of each reagent is required to complete the reaction; but in other cases several molecules of each may be necessary.

One molecule of silver nitrate and one molecule of potassium iodide will react upon each other to form one molecule of silver iodide and one molecule of potassium nitrate, thus:—

$AgNO_3 + KI = AgI + KNO_3$.

In the preparation of solution of chloride of antimony, one molecule of

sulphide of antimony reacts with six molecules of hydrogen chloride, thus:—

$$Sb_2S_3 + 6HCl = 2SbCl_3 + 3H_2S.$$

In the preparation of sodium valerate the reaction involves three mole-cules amylic alcohol, two molecules potassium bichromate and eight mole-cules sulphuric acid, thus:—

$$3C_5H_{12}O + 2K_2Cr_2O_7 + 8H_2SO_4 = 3C_5H_{10}O_2 + 2K_2SO_4 + 2(Cr_2SO_4)_3) + 11H_2O.$$

637. Both Sides must be Equal.—Both members of the chemical equation must contain the same kind and number of atoms, and the sum of the molecular weights on one side of the equality sign must be equal to the sum of the molecular weights on the other side.

638. The student must learn the use of symbols and how to write for-mulas and equations by actual practice. This can best and most safely be accomplished with the aid of a competent teacher, who will point out any errors. All that is necessary for the present is that the student shall thor-oughly memorize the symbols employed to represent the most important ele-ments, which are as follows :

Element.	Symbol.	Element.	Symbol.
Hydrogen.	H.	Strontium.	Sr.
Fluorine.	F.	Barium.	Ba.
Chlorine.	Cl.	Magnesium.	Mg.
Bromine.	Br.	Zinc.	Zn.
Iodine.	I.	Cadmium.	Cd.
Oxygen.	O.	Aluminum.	Al.
Sulphur.	S.	Cerium.	Ce
Carbon.	C.	Chromium.	Cr.
Silicon.	Si.	Manganese.	Mn.
Tin.	Sn.	Iron.	Fe.
Boron.	B	Nickel.	Ni
Nitrogen.	N.	Cobolt.	Co.
Phosphorus.	P.	Lead.	Pb.
Arsenic.	As.	Copper	Cu.
Antimony.	Sb.	Mercury.	Hg.
Bismuth.	Bi.	Gold.	Au.
Lithium.	Li.	Silver.	Ag.
Sodium	Na.	Platinum.	Pt.
Potassium.	K.	Molybdenum.	Mo.
Calcium.	Ca.	Tungsten.	W.

The symbols of all known elements will be found on pages 112-113, and the origin of each symbol will also be found on the same pages, as the table there given includes the Latinic titles of all the elements (465)

The memorization of the symbols of important elements is absolutely necessary before the student can make much progress in the study of chemistry.

639. After the student has perused the whole number of pages devoted

to chemistry in this book he should return to a study of this chapter and learn it thoroughly.

Doubtless the student will find this chapter difficult to grasp at this stage; but after reading chapters XL. to XLII. he should read this again.

CHAPTER XXXI.

THE ELEMENTS.

640. General Review.—Of the seventy elements about four-fifths are *metals*, the remainder being called *non-metallic elements*. It is impossible, however, to draw the line absolutely between metallic and non-metallic elements, because several elements partake more or less of the characteristics of both classes, physically as well as chemically.

641. The metals are:

Aluminum,	Erbium,	Molybdenum,	Tantalum,
Antimony,	Gallium,	Nickel,	Tellurium,
Arsenic,	Germanium,	Osmium,	Terbium,
Barium,	Glucinum,	Palladium,	Thallium,
Bismuth,	Gold,	Platinum,	Tin,
Cadmium,	Indium,	Potassium,	Titanium,
Cæsium,	Iridium,	Rhodium,	Tungsten,
Calcium,	Iron,	Rubidium,	Uranium,
Cerium,	Lanthanum,	Ruthenium,	Vanadium,
Chromium,	Lead,	Samarium,	Ytterbium,
Cobalt,	Lithium,	Scandium,	Yttrium,
Columbium,	Magnesium,	Silver,	Zinc,
Copper,	Manganese,	Sodium,	Zirconium.—57.
*Didymium,	Mercury,	Strontium,	

642. The non-metallic elements are:

Boron,	Hydrogen,	Selenium,
Bromine,	Iodine,	Silicon,
Carbon,	Nitrogen,	Sulphur.—13.
Chlorine,	Oxygen,	
Fluorine,	Phosphorus,	

*(Split into two metals.)

643. The preceding classification is wholy artificial and based upon external appearances and physical properties, especially upon metallic lustre or want of it, tenacity or want of it, etc.

It is true that *in some instances* elements which naturally fall into characteristic groups according to their chemical properties and compounds are not separated; but *in other instances* well defined natural groups are broken by this artificial classification.

644. Sometimes arsenic antimony, bismuth, and tellurium are classed with the non-metallic elements, the three first named because they are so closely related to nitrogen and phosphorus which are unquestionably non-metallic, and tellurium because it so much resembles sulphur in its chemistry. But if these metallic substances are to be classed with the non-metallic for chemical reasons, there are other metals, as tin, molybdenum and tungsten, which might with equal propriety be classed among the non-metals.

645. State of Aggregation.— The metals, with but one exception, are solid. The exception is mercury, which is liquid under ordinary conditions, solid below—40° C. (—40° F.), and vaporizes at +350° C. (662°. F.).

Of the non-metallic elements boron, carbon, iodine, phosphorus, selenium, silicon and sulphur are solids; bromine is a liquid; and chlorine, fluorine, hydrogen, nitrogen and oxygen are gases.

646. Fusibility of the Solids.—All the metals are fusible, some of them at temperatures below the boiling point of water, some only at extremely high temperatures, others between these extremes.

Among the solid non-metallic elements boron, carbon and silicon are infusible.

647. Volatility.—Mercury, potassium, sodium, zinc, magnesium, cadmium and arsenic can be distilled; tellurium and antimony can be distilled only with a current of hydrogen.

Of the non-metallic elements iodine, phosphorus, selenium, sulphur and bromine are vaporizable.

648. Crystallization.—Many of the metals are crystalliza-

ble; the greater number of these form cubes or regular octo-
hedrons; tellurium, arsenic and antimony crystallize in rhombo-
hedrons of the hexagonal system.

Bismuth, zinc, copper, lead, tin, silver and gold all crystal-
lize.

All the solid non-metallic elements are crystallizable.

649. **Opacity** is given as one of the properties by which
metals may be distinguished from the non-metallic elements.
But gold in thin layers placed between two plates of glass trans-
mits greenish light.

Of the solid non-metallic elements boron, carbon (as char-
coal, coal and graphite) iodine, selenium, silicon and sulphur
are opaque; while phosphorus is translucent, and carbon as dia-
mond is alone transparent.

650. **Lustre.**—The metals possess a peculiar lustre, espe-
cially when polished. Some metals have this quality in much
higher degree than others.

But boron, carbon (as diamond and as graphite), silicon,
iodine and sulphur also possess a lustre.

651. **Color.**—When in compact masses the metals have
usually a white color with a more or less marked tendency
toward grayish or bluish; but barium, calcium and gold have
a yellowish or yellow color, and copper is reddish.

In this respect the non-metallic elements vary greatly among
each other and from the metals.

652. **Density.**—The specific weights of about two-thirds of
the metals exceed 5; but of the remainder several have specific
weights below two. Of some of the heavy metals (674) the
specific weights exceed 10, the heaviest being Platinum 21.5 and
iridium 22.4. It is commonly stated that metals, as a rule, have
higher specific weights than the non-metallic elements, but
more than one-half of the non-metallic elements have specific
weights ranging from 1.83 to 4.95. Really we can only say in
this direction that the specific weights of two-thirds of the
metals are higher than those of any non-metallic elements, and
the specific weights of several non-metallic elements are lower

than those of any metals, while the specific weights of the greater number of the non-metallic elements are higher than those of the alkali-metals (676) and several of the alkaline earth metals (678). In fact, several elements which resemble the non-metallic elements more than they resemble metals in their chemical properties have higher specific weights than many undoubted metals which are chemically farthest removed from the non-metallic elements.

653. Metals are relatively better CONDUCTORS OF HEAT AND OF ELECTRICITY than non-metallic elements. But the metals exhibit these properties in a high degree only when in solid, compact masses; obtained in a state of fine division by precipitation they are far less effective conductors of electricity and heat.

654. **Tenacity, ductility and malleability** are properties belonging to many of the metals, and to none of the non-metallic elements. But there are also many metals which do not possess these properties, as bismuth, antimony, arsenic, manganese, chromium, zinc, tungsten, molybdenum and vanadium.

655. **Solubility.**—No metal is soluble in any simple solvent. Most metals are soluble chemically in the stronger acids, and some also in strong alkalies; others only in "aqua regia."

Of the non-metallic elements boron, carbon and silicon are insoluble in all simple solvents; but iodine and bromine are soluble in alcohol and in glycerin; phosphorus, selenium and sulphur in fixed oils and carbon disulphide.

656. **Occurrence in Nature.**—Gold, silver, mercury, copper, lead, bismuth, arsenic and antimony occur free or uncombined. The metals of the platinum group occur together in the so-called platinum ore and osmium-iridium, in a metallic state. Iron and nickel, in the free state, occur in meteors. No other metals occur uncombined. It is also to be observed that silver, mercury, copper, lead, arsenic, antimony, iron and nickel occur only in small quantities uncombined, and in much larger amounts in their native compounds.

The most common forms in which heavy metals exist in nature

is in chemical combinations with oxygen and sulphur, and less frequently with other non-metallic elements and compound radicals.

Of the non-metallic elements carbon (as graphite and diamond), nitrogen, oxygen and sulphur are found uncombined. These are also found, and in much larger quantities, combined with other elements: carbon and nitrogen chiefly with non-metallic elements in organic substances; oxygen with hydrogen in water, with silicon in silica, with nearly all the metals, and with carbon and hydrogen in organic substances; while sulphur occurs mostly combined with iron, copper, lead, zinc and other metals. Bromine, chlorine, fluorine and iodine (the "halogens") occur combined with sodium and other metals; and the remainder of the non-metallic elements chiefly combined with oxygen.

Of all the seventy elements oxygen is the most abundant, then probably silicon, aluminum, iron, calcium, carbon and hydrogen.

657. Alloys and Amalgams.—Some of the metals combine with each other, sometimes in definite proportions, forming even crystallizable compounds. The most interesting compound of this kind is one consisting of two atoms of antimony and three atoms of zinc. The chemical union of metals in definite atomic proportions, and in accordance with their valence, is attended with the evolution of heat, which is strong additional evidence that the union is a true chemical re-action. ·

But mixtures of metals prepared by fusing them together, in proportions other than such as would be in accord with the atomic weights, are commonly employed in the mechanical arts, and they are called *alloys*. These alloys probably contain true chemical compounds of the metals, which, in a state of fusion, are soluble in (or miscible with) each other. That this is the case is indicated by the fact that when the molten mass is rapidly cooled a homogeneous mass in obtained; while, if the cooling be slow, the less readily fusible compounds may crystallize out, leaving the more fusible alloy still in a liquid state,

so that, when the whole has become cold, the mass is not uniform.

A most striking property of alloys is the fact that their fusing points are lower than those of their constituents.

Thus cadmium melts at 315° C. (599° F.), tin at 227°.8 C. (442° F.), lead at 325° C. (617 F.), and bismuth at 264° C. (507° F.); yet an alloy (Wood's) made of 1 to 2 parts of cadmium, 2 parts of tin, 4 parts of lead, and 7 to 8 parts of bismuth melts at from 66° to 71° C. (150°.8 to 159°.8 F).

Arcet's alloy is made of 8 parts of bismuth, 5 parts of lead, and 3 parts of tin, and melts at 94°.5 C. (202° F.).

Brass, bronze, gun metal, bell metal, German silver, type metal, pewter, britannia metal, solder, coin metal, and several other metallic substances are alloys.

The alloys formed by mercury are called *amalgams*.

658. But the alloys, although they evidently contain true chemical compounds, retain the essential metallic characteristics of the constituents in a high degree, thus differing very greatly from other chemical compounds in which the characteristic physical properties of the component elements are generally obliterated. The alloys are the only chemical compounds formed by the metals with each other.

659. The non-metallic elements, on the other hand, form with each other numerous chemical compounds of the most varied nature, and they also severally combine with the metals. When a non-metallic element combines with another non-metallic element or with a metal the compound formed is usually radically different from either of the elements entering into that compound.

660. We have seen that the only compounds which metals form with each other resemble in their essential physical properties the metals of which they are composed (658). They are solid, hard, opaque, lustrous, tenacious, ductile, malleable, or brittle, according to the character of their component metals in these respects, and their color also is such as would naturally result by a mere physical mixture of the constituents.

661. But when non-metallic elements enter into chemical compounds, the state of aggregation, density, consistence, color, solubility, and other physical properties of the compounds have apparently no relation to the properties of the component elements (662).

662. Oxygen and hydrogen are gases; they can be compressed to the liquid state only by the aid of tremendous pressure and extreme cold; but when they combine chemically with each other the compound formed is water.

Carbon can not, by any means at present known, be converted into a liquid or a gas; it is infusible and fixed. But the compounds of carbon with oxygen, hydrogen and nitrogen, are gases, liquids and solids.

Iodine is a bluish-black solid of a peculiar, penetrating odor; but its compound with hydrogen is a colorless gas having a very different odor.

Carbon, in its ordinary condition, is a black solid; sulphur is a yellow solid; both are inodorous. But the compound of carbon and sulphur is a colorless, offensively odorous liquid.

Mercury is a bluish-white, shining liquid metal, and oxygen, a colorless gas: but they form two different compounds with each other, both solids, one of them either orange red, brick red or orange yellow, the other, grayish black.

663. Numerous other examples might be given to illustrate the radical change of properties which follows chemical reactions in which the non-metallic elements are concerned.

Indeed, it would seem as if these striking differences between the metals and the non metallic elements afforded reasons stronger than any others for the classification of the elements into metallic and non-metallic. Yet these striking distinctions, as far as they extend, are not lost by the more natural classification of the elements according to their chemical behavior and the character of their compounds, but are rather brought out more clearly.

664. The fact that the properties of the elements bear some simple relation to their atomic weights seems to be beyond doubt. It has been formulated in the conclusion that "the chemical properties of the elements are a periodic function of their atomic weights." The atomic weights in many instances differ by the number, 16, representing the atomic weight of oxygen (H=1), or by a number which is nearly a multiple of 16. It has also been shown that these simple differences are to be observed between the atomic weights of elements possessing many similarities in chemical behavior. Further, it has been found that in many natural groups of elements the atomic weight of one member is frequently one-half of the sum of two other members, etc. Many chemists have tabulated the elements in various ways to bring out these periodic co-incidences, in the hope of finding a true explanation of them. The most complete table of this kind is that of the Russian chemist, Mendeleeff. The properties which seem to bear such a periodic relation to the atomic weights include: relative electro-chemical polarity, valence, specific weights, atomic volumes, specific heat, etc. Mendeleeff's table is as follows:

TABLE OF ELEMENTS NATURALLY GROUPED IN ACCORDANCE WITH THEIR ATOMIC WEIGHTS.
(BASIS OF ATOMIC WEIGHTS: H =1.)

I.	II.	III.	IV.	V.	VI.	VII.	VIII.
H, 1.							
Li, 7.	Gl, 9.	B, 11.	C, 12.	N, 14.	O, 16.	F, 19.	
Na, 23.	Mg, 24.3	Al, 27.	Si, 28.3	P, 31.	S, 32.	Cl, 35.4	
K, 39.	Ca, 40.		Ti, 48.	V, 51.	Cr, 52.	Mn, 55.	Fe, 56. Co, 58.6 Ni, 58.6
Cu, 63.2	Zn, 65.1	Ga, 70.		As, 75.	Se, 79.	Br, 79.8	
Rb, 85.2	Sr, 87.3	Yt, 89.	Zr, 90.4	Cb, 93.7	Mo, 96.		Ru, 101.4 Rh, 103. Pd, 106.4
Ag, 107.7	Cd, 111.5	In, 113.6	Sn, 119.	Sb, 120.	Te, 125.	I, 126.5	
Cs, 132.7	Ba, 137	La, 137.9					
		Ce, 140					
		Di, 142					
		Er, 166		Ta, 182.	W, 183.6		
		Tl, 193.7	Pb, 206.4	Bi, 209			Os, 190.3 Ir, 192.5 Pt, 194.3 Au, 196.7
Hg, 200.			Th, 232		U, 239.		

CHAPTER XXXII.

OXYGEN, HYDROGEN AND SULPHUR.

665. Oxygen (O; at. w. 16) is a colorless, odorless, taste-less gas, which constitutes over one-fifth of the weight of the air.

One liter of O_2 at $0°$ C. and $760\ mm$ barometric pressure weighs 1.43 Grams.

Water is composed of 8 parts of oxygen and 1 part of hydrogen, chemically united, nearly one-half of the weight of the rocks is oxygen, and a large proportion of oxygen is also contained in the earths and soils and in plants and animals. Its great abundance in nature is in itself sufficient evidence of its vast importance.

666. *Preparation.*—Certain compounds containing O are easily decomposed, giving up their O when heated, and these compounds are, therefore, utilized in making the O_2. The most common materials employed for that purpose are oxide of mercury, HgO, and potassium chlorate, $KClO_3$. Both part with all of their oxygen when heated: $2HgO = 2Hg + O_2$ and $2KClO_3 = 2KCl + 3O_2$. [When the potassium chlorate is mixed with about one-fourth of its weight of manganese dioxide ("black oxide of manganese") the decomposition progresses more quietly and evenly, although the manganese dioxide does not take part in the reaction.]

667. Oxygen combines with all other elements except fluorine alone. **Oxidation** is the union of oxygen with other elements, or with compound radicals (804). Chemical combination with oxygen, or oxidation, is one of the most common and important of chemical reactions. When oxidation is very rapid and accompanied by the evolution of heat and light it is called fire or *combustion*. Substances which take up oxygen and become chemically united with it are said to be *oxidized*. Oxidization is necessary to the existence of plants and animals. Respiration is a process of oxidation.

668. But although oxygen plays such an important rôle in

animal and plant life, and forms compounds with all other elements but one (667), it exhibits no great chemical energy at ordinary temperatures.

669. The compounds formed by the union of positive radicals with oxygen are called *oxides*.

670. When H is *ignited* the product of its combustion is water, H_2O; the product of the combustion of S is the irritating gas SO_2; P, when burned, forms P_2O_5, which is a white solid; Mg when ignited burns with a brilliant flame, producing " magnesia," MgO; and three pounds of the metal will, when " consumed " by the fire, leave five pounds of ashes, consisting of the oxide; carbon, as charcoal or coal, forms CO_2 when its combustion is completed in a free supply of O_2, or CO if the supply of O_2 is deficient; alcohol, oil, and other organic substances, when burned, produce CO_2 and H_2O.

The most intense degree of heat obtainable by combustion is produced when a mixture of H_2 and O_2 in proper proportions is ignited.

671. **Ozone** is a molecule of three oxygen atoms: $\overset{O}{\underset{O-O}{}}$ or O_3. It has a peculiar odor, which is noticed sometimes in a place where lightning has just struck, or in a room where an electrical machine is in operation. Ozone has a powerful chemical energy, causing, at ordinary temperatures, the oxidation of metals which can not be oxidized by ordinary oxygen, decomposing potassium iodide, and destroying vegetable colors.

672. Oxygen is the strongest electro-negative element. It is always bivalent. It is, therefore, capable of linking together the most strongly electro-positive metals with the strongest electro-negative elements, like sulphur, nitrogen, etc., to form neutral stable compounds called *salts*. The oxides of strongly electro-negative elements form acids (with water), while the oxides of strongly electro-positive elements, as potassium, sodium, calcium, etc., form bases (with water).

673. Oxygen, then, is present in all hydroxyl acids (884), bases (874), and oxy-salts (900). It may, therefore, be truly termed the principal salt-former, being the only constituent in

the true salts (oxy-salts), and performing, in the formation of the salt molecule, the important function of uniting the positive to the negative radical.

Oxygen is also present in several of the most important compound radicals, as in HO, CO, NO_2, etc., and compound radicals containing O, but not H, are always negative.

674. Hydrogen (H; at. w. 1) is a colorless, odorless, tasteless gas. It does not exist free. Its most abundant and wonderful compound is its oxide, called water, of which it constitutes one-ninth by weight. It is also present in most of the organic substances, animal or vegetable.

One liter of H_2 at 0° C., barometer at 760 mm, weighs 0.08958 Gram (called 1 *crith*). It is the lightest of all gases.

675. A mixture of H_2 and O_2, when ignited, explodes with great violence, except when a current of the mixed gases issues from a tube through a small orifice, as in the *oxy-hydrogen burner*. The product is water. But water is decomposed by electrolytic action into its two component elements.

676. *Preparation.*—H_2 is produced by the action of zinc upon sulphuric acid or hydrochloric acid : $Zn+H_2SO_4=$ $Zn SO_4+H_2$ and $Zn+2HCl=ZnCl_2+H_2$.

Hydrogen is also formed together with CO by the decomposition of water resulting when steam is passed over coal heated to an intense temperature :

$2H_2O+C_2=2CO+2H_2$. This mixture of CO and H_2 is called *fuel gas* and *water gas*.

677. H_2 is, at a high temperature, a powerful reducing agent ; that is, it has a strong affinity for oxygen, and, therefore, removes O from oxides and other molecules.

678. Water may be regarded either as the oxide of hydrogen, H_2O, or as hydrogen hydrate, HOH. It is colorless, odorless, tasteless and entirely neutral. At the ordinary temperatures it is liquid ; its boiling point is 100° C. (212° F.), and its freezing point 0° C. (32° F.). Its vapor is called *steam*, and congealed water is called *ice*. Its maximum density is attained

at 4° C. (39°.2 F.). Its vapor density is 9 ; Sp. w. at 4° C. = 1; mol. w. 18.

The wonderful oxide of hydrogen—water—does not form any salt ; but it forms acids with the acid-forming oxides, and bases with the base-forming oxides.

Water is the most important of all solvents.

679. Natural water—that contained in the ocean, lakes, rivers, springs, wells and clouds—is not pure.

Sea water contains much salts.

Spring water is called *hard water* because it generally contains calcium acid carbonate, and produces insoluble compounds with soap in washing.

Well water is frequently contaminated with organic substances, which are the products of decomposing animal or vegetable matter.

Lake water and *river water* are often comparatively pure and soft, or nearly free from calcium compounds and other substances.

Rain water, collected after the air has been purified by the first part of the shower, and in such a manner that the water has not come in contact with roofs or other dusty or soiled objects, is the cleanest natural water obtainable.

680. Distilled water, carefully made, is the only perfectly pure water. Natural water contains both volatile and fixed impurities. When it is distilled the volatile constituents accompany the first portion of the water vapor ; the first portion of the distillate is, therefore, rejected. The distillation is discontinued before all of the water has been vaporized, because there may be fixed organic substances present which might be decomposed by the heat when the water remaining in the still, flask, or retort, is but a small quantity.

Distilled water must be used for all chemical and pharmaceutical purposes where calcium compounds, chlorides, sulphates, carbon dioxide, ammonia, and other impurities common to natural water are objectionable.

681. Peroxide of hydrogen is H_2O_2, or H—O—O—H, or

HO united to OH. It is a colorless syrupy liquid, which acts
as a powerful bleaching and oxidizing agent, because it is easily
decomposed, giving up one-half of its oxygen, and thus becom-
ing reduced to water. A solution of peroxide of hydrogen is
used in medicine, its value being dependent upon the oxygen
which is being constantly liberated in it by the decomposition
of the peroxide of hydrogen.

682. Hydrogen does not under ordinary conditions exhibit
any marked affinity for other elements, except for chlorine and
bromine ; but at high temperatures it has great affinity for
oxygen and is, therefore, often employed as a reducing agent.

683. Hydrogen is always univalent (612). In its chemical
behavior it is radically different from oxygen. It stands in
the middle of the electro-chemical series (572) separating the
relatively negative from the relatively positive elements. It
generally acts as an electro-positive radical, but in many mole-
cules containing hydrogen all or part of that hydrogen may be
replaced by oxygen, chlorine, and other negative radicals.

The hydrogen atom is, therefore, a frequently occurring
radical. Thus in HCl it is positive, in KOH it is regarded as
negative, and in HOH as both. It shares with oxygen the dis-
tinction of forming many compound radicals, especially with
quadrivalent and trivalent elements ; but there is this notable
difference that the compound radicals containing oxygen are
generally acid radicals while those containing hydrogen are
basic.

684. Although it may be said that hydrogen occupies the neutral ground
between the univalent radicals, chlorine at one extreme (strongly negative)
and potassium at the other end (strongly positive), yet it has been recognized
that hydrogen stands much closer to the metals than to chlorine. It has,
indeed, been called the *gaseous metal*. An alloy of hydrogen with palladium
has been made, and a medal consisting of that alloy, containing nine hun-
dred volumes of hydrogen, was once produced. Later hydrogen was com-
pressed by Pictet (at the close of 1877) into a steel-blue liquid; a portion of this
liquid solidified, being deprived of its latent heat by the vaporization of another
portion, and the solid pieces of hydrogen, striking the ground as they fell,
produced a shrill metallic sound.

685. Hydrogen is contained in all acids as positive hydrogen, and may be displaced from its position in the acid molecule by any other positive radical. It is contained in all bases as relatively negative hydrogen, and may be displaced from the molecule of a base by any other negative radical. In this respect then it acts wholly differently from oxygen, for the oxygen of an acid or a base is not thus displaced. Thus the hydrogen in acids and bases is a relatively weak radical.

686. With the halogens (696) hydrogen forms binary compounds called hydrogen acids, which have the strongly marked corrosive and sour properties of true acids (hydroxyl acids), and which form with the bases other binary compounds resembling the salts and called *haloids*. Hydrogen is displaced from its position in the molecule of hydrogen-acids by other positive radicals, for the hydrogen in hydrogen-acids as well as in hydroxyl acids is positive hydrogen.

687. With nitrogen hydrogen forms a strongly alkaline body called ammonia—the very opposite of acids in its properties; while oxygen forms with nitrogen several oxides, one of which produces one of our strongest acids—nitric acid—when it reacts with water.

688. Hydrogen and oxygen are, together with carbon and nitrogen, the most important elements in organic chemistry. But they play entirely dissimilar rôles.

With carbon hydrogen forms many compounds which are even more neutral, or chemically indifferent, toward other substances than the oxide of hydrogen.

689. Among the compound radicals formed by hydrogen are HO, NH_4, NH_2, NH, HS, CH_3, C_2H_5, CH_2, CH, C_3H_5, and numerous others. All compound radicals containing hydrogen but not oxygen exhibit electro-positive polarity.

690. Sulphur (S ; at. w. 32.) is under ordinary conditions a yellow solid, odorless and tasteless, insoluble in water and in alcohol, but soluble in fixed and volatile oils. Melts at 115° C.; boils at 448° C.

It occurs free as well as combined, its most important compounds being the sulphides (854) and sulphates (907).

The sources of the sulphur of commerce are the native sulphur and *iron pyrites*.

Sulphur occurs in two forms—hard and soft. The soft plastic sulphur is obtained by heating the common sulphur at 200.° to 250.° C.

In commerce we find roll sulphur ("brimstone"), sublimed sulphur ("flowers of sulphur"), washed sulphur (U. S. P.), and precipitated sulphur.

691. Like oxygen, sulphur is an artiad (611). The atomic weight of S is precisely twice that of O.

At ordinary temperatures sulphur exhibits no marked chemical energy ; but at high temperatures it has a strong affinity for the metals, oxygen, and some other elements.

The compounds formed by positive radicals with S are called sulphides (854).

692. Many of the compounds of sulphur are analogous to the compounds of oxygen. Thus the acid-forming oxides are to some extent paralleled by analogous sulphides, the base-forming oxides are also represented by corresponding basic sulphides, and there are sulphur salts which resemble the oxy-salts in structure, the only difference being that one series contains atoms of sulphur where the other series contains the same number of atoms of oxygen in the same relative position.

The following oxygen compounds and sulphur compounds will suffice to show their analogy :

Carbon Dioxide	CO_2	CS_2	Carbon Disulphide
Hydrogen Oxide	H_2O	H_2S	Hydrogen Sulphide
Ferrous Oxide	FeO	FeS	Ferrous Sulphide
Calcium Oxide	CaO	CaS	Calcium Sulphide
Ferric Oxide	Fe_2O_3	Fe_2S_3	Ferric Sulphide
Arsenous Oxide	As_2O_3	As_2S_3	Arsenous Sulphide
Arsenic Oxide	As_2O_5	As_2S_5	Arsenic Sulphide
Sodium Carbonate	Na_2CO_3	Na_2CS_3	Sodium Sulpho-carbonate

In all these compounds, in which sulphur occupies a position analogous to that of the electro-negative oxygen, the sulphur acts as a *dyad*. But in all

molecules and radicals in which sulphur is united to oxygen, the sulphur thus playing the rôle of a positive element, it is *apparently* a tetrad or a hexad.

Selenium and *Tellurium* resemble sulphur in their chemistry.

693. The oxides of sulphur are sulphurous anhydride, SO_2, and sulphuric anhydride, SO_3.

Sulphurous anhydride, or sulphur dioxide, is formed when sulphur is burned in air, and is the "sulphurous vapor" observed in igniting sulphur matches, and which is so irritating to the air passages. Dissolved in water it forms *sulphurous acid*. It has strong bleaching properties.

The sulphuric oxide, or sulphuric anhydride, or sulphur trioxide, is not so readily prepared ; but the acid it forms when brought in contact with water is familiar to us under the name of sulphuric acid, which is chemically the strongest of all acids and terribly corrosive.

694. Sulphuric acid is prepared by first burning sulphur (or *pyrites*) to form SO_2, which is conducted into a lead chamber, where it comes in contact with N_2O_4 (generated separately), water vapor and air. The SO_2 is oxidized at the expense of the N_2O_4 to SO_3:

$2SO_2 + N_2O_4 = 2SO_3 + N_2O_2.$

The N_2O_2 then takes up O from the air, forming N_2O_4 again :

$N_2O_2 + O_2 = N_2O_4.$
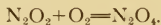
The SO_3 forms sulphuric acid with the water :

$SO_3 + H_2O = H_2SO_4.$
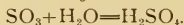
Sulphuric acid is one of the most useful of all the strong acids, because it decomposes numerous other compounds on account of the strongly electro-negative polarity of the sulphate radical. Other acids are thus prepared by decomposing their salts by sulphuric acid.

The official sulphuric acid is nearly absolute H_2SO_4, being required to contain at least 96 per cent. It is an oily, colorless liquid of 1.840 sp. w. (water = 1).

695. With hydrogen, S forms the colorless gas H_2S, known as hydrogen sulphide, or sulphuretted hydrogen, or hydrosul-

phuric acid, or sulphydric acid. This gas has the odor of rotten eggs, and is poisonous when inhaled. It is soluble in water. Its principal use is as a chemical reagent for the precipitation of the heavy metals from the solutions of their salts, which is possible because these sulphides are insoluble in water.

It is prepared from ferrous sulphide by the action of sulphuric acid :

$$FeS + H_2SO_4 = FeSO_4 + H_2S.$$
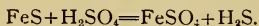
CHAPTER XXXIII.

THE HALOGENS.

696. The Halogens are a characteristic group of the four elements: fluorine, chlorine, bromine, and iodine. The chemical energy of fluorine is so intense that it has not been possible to study its properties in the free state. Chlorine is a gas, and is endowed with very energetic chemism. Bromine is a liquid and also energetic. Iodine is a solid and has strong chemical energy, too, although relatively weaker than that of the other halogens. They form, respectively, chlorides, bromides, and iodides with the metals.

But in cases where one metal forms two different series of haloids, the most stable chlorides, relatively, are the higher (or-"ic") chlorides, while the most stable iodides are the lower (or-"ous") iodides, and the bromides do not exhibit any marked difference as between the higher and lower.

697. The term "halogen" means *salt-former*. These elements are so called because they form with metals and positive compound radicals a class of compounds in many respects resembling the salts produced by the union of oxyacids with bases. They constitute a class of salt-formers very different from oxygen and sulphur. This is in some measure accounted for by the fact, that, while oxygen and sulphur are dyads, the halogens are monads. But when the dyad salt-formers are placed beside the monad salt-formers, with the atomic weights appended, the exhibit becomes intensely interesting. Here they are:

Dyad Salt-Formers.		Monad Salt-Formers.	
	Atomic Weight.	*Atomic Weight.*	
Oxygen	16	19	Fluorine
Sulphur	32	35.4	Chlorine
Selenium	79	80	Bromine
Tellurium	125	127	Iodine

698. Oxygen, we have said, is the strongest electro-negative element; we may add now that fluorine is the strongest electro-negative monad.

No compound of oxygen and fluorine is known.

As to the remaining three members of each group, it should be observed that the atomic weights of the middle members, selenium on one side and bromine on the other, are very nearly half of the sums of the other two, a coincidence which recurs in other groups of elements. It should also be remembered that these elements stand in their groups in exactly the same order as in the electro chemical series.

699. Chlorine, and its fellow halogens, do not exhibit a strong affinity for oxygen, notwithstanding their energetic action upon metals and hydrogen compounds. This is significant. To induce chlorine to combine with oxygen it is necessary to strengthen the attraction between these elements by the presence of a strong base—or, in other words, to take advantage of the predisposing affinity (548) of that base for the united chlorine and oxygen. It is also to be observed that *negative chlorine*—the salt former—is always univalent, but the *positive chlorine* which enters into chemical union with oxygen is *apparently*, as a rule, polyvalent.

700. Chlorine.—(Cl; at. w. 35.4) is a yellowish green gas of suffocating odor, soluble in water to the extent of 0.6 per cent. at about 10°C. At 15° C. and under the pressure of four atmospheres it can be rendered liquid. Chlorine does not occur free, but it exists abundantly in the combined state in the chlorides of potassium and sodium.

Chlorine gas is poisonous when inhaled.

One liter of chlorine weighs 3.17 Grams.

701. *Preparation.*—It is best prepared by the mutual decomposition of hydrochloric acid and manganese dioxide (black oxide of manganese): $MnO_2 + 4HCl = Cl_2 + MnCl_2 + 2H_2O$.

702. Chlorine forms four different *oxides*, namely:

Cl_2O = hypochlorous oxide or anhydride;

Cl_2O_3 = chlorous oxide or anhydride;

Cl_2O_5 = chloric oxide or anhydride; and

Cl_2O_7 = perchloric oxide or anhydride.

These oxides form with water, respectively, hypochlorous, chlorous, chloric and perchloric acid. These acids are unstable.

703. With hydrogen Cl forms a gas called hydrochloric acid, or hydrogen chloride, the solution of which is one of the most important of the strong acids. This acid is prepared by decomposing sodium chloride (common salt) with sulphuric acid:

$$NaCl + H_2SO_4 = NaHSO_4 + HCl.$$
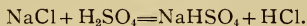
Impure commercial hydrochloric acid is commonly called "muriatic acid."

The hydrochloric acid of the Pharmacopœia is a water solution containing 31.9 per cent. of HCl.

Other chlorides are referred to elsewhere (860).

704. The affinity of chlorine for hydrogen is remarkable. It is capable of removing hydrogen atoms from organic molecules. Each molecule of chlorine consists of two atoms; one of these atoms unites with the atom of hydrogen while the other chlorine atom usurps the former position of that hydrogen atom in the organic compound. In numerous cases the chlorine seems, indeed, to remove the hydrogen even from its combinations with oxygen, after which the oxygen, in its nascent state, vigorously attacks other substances present.

"Bleaching powder," or "chlorinated lime" (generally misnamed "chloride of lime") contains as its only valuable constituent the unstable salt calcium hypochlorite, and the "solution of chlorinated soda" (or "Labarraque's solution") contains sodium hypochlorite. These preparations are easily decomposed, yielding free chlorine, and their value depends upon the amount of Cl_2 they yield.

705. **Bromine (Br** ; at. w. 79.85) is a dark, reddish-brown, heavy, volatile liquid, having an extremely irritating odor. When inhaled it is poisonous, and its vapor attacks the eyes and air passages dangerously. It must, therefore, be kept and handled with great care, and is usually put up in glass stoppered bottles imbedded in clay enclosed in a tin box. It is insoluble in water, but soluble in alcohol, ether, chloroform and carbon disulphide, and freely soluble in solutions of iodides and bromides.

It occurs in the bromides of salt springs.

706. *Preparation.*—Bromide of potassium, sodium, or magnesium may be used as the material for the production of Br_2, the salt being decomposed by passing the stronger electronegative element chlorine into a water solution of the bromide : $2KBr+Cl_2=Br_2+2KCl$.

707. A solution of hydrogen bromide, containing 10 per cent. of the HBr, is official under the name of *hydrobromic acid*. It is a strong acid, and may be made by decomposing potassium bromide with sulphuric acid, a mixture of these two substances being subjected to distillation: $KBr+H_2SO_4=KHSO_4+HBr$.

The bromides are referred to elsewhere (866).

708. Iodine (I ; at. w. 126.5) is a crystalline, lustrous, blackish, brittle solid, having a peculiar penetrating odor. It is practically insoluble in water, but readily soluble in a solution of potassium iodide ; it is also soluble to the extent of nearly 10 per cent. in alcohol, and less freely in fixed oils and in glycerin. Ether, chloroform and carbon disulphide dissolve I_2 rather freely.

It liquefies at 113° C., and boils at 200° C.; but violet vapors of iodine are produced when the I_2 is heated at much lower temperatures.

Iodine occurs in the iodides of salt springs and sea water. It is *prepared* out of the ashes of sea-weeds which contain iodides.

709. Hydrogen iodide, or hydriodic acid, is so unstable that its water solution can not be preserved from decomposition ; but the addition of a large quantity of sugar retards that decomposition and hence there is an official " syrup of hydriodic acid."

CHAPTER XXXIV.

THE NITROGEN GROUP AND BORON.

710. Nitrogen (N; at. w. 14) is a colorless, odorless, tasteless gas, which constitutes four-fifths of the weight of the air. By extreme cold and pressure it can be rendered liquid. It is neither combustible nor a supporter of combustion.

Combined with other elements nitrogen is contained in albuminous substances, alkaloids, and certain other organic substances.

One liter of nitrogen weighs 1.25 Grams.

711. The *oxides* of N are five:

$$N_2O = \text{nitrogen monoxide.}$$
$$N_2O_2 = \text{`` dioxide.}$$
$$N_2O_3 = \text{`` trioxide.}$$
$$N_2O_4 = \text{`` tetroxide.}$$
$$N_2O_5 = \text{`` pentoxide.}$$

The trioxide and tetroxide are liquids; the others, gases. The trioxide is blue; the tetroxide, red; the others, colorless.

N_2O is often called "nitrous oxide gas," or "laughing gas," and is used as an anæsthetic by dentists. It is prepared by heating dry ammonium nitrate: $NH_4NO_3 = 2H_2O + N_2O$.

712. When nitric acid acts upon metals the acid is usually decomposed, giving of N_2O_2; this takes up more oxygen from the air, forming red vapors of N_2O_4.

713. Nitrogen exhibits chemical properties wholly different from those of the dyad salt-formers, the monad salt-formers, and hydrogen. The fact that nitrogen is trivalent must, of itself, distinguish its chemistry from that of either oxygen, sulphur, hydrogen, or chlorine.

Nitrogen is even more indifferent in its chemical combining energy than oxygen, sulphur, and hydrogen. It does not unite directly with other elements even at high temperatures. To compel the nitrogen atoms to separate from each other and unite with other elements unusual means are necessary; the chemical affinity must be re-inforced by such favorable conditions as the *status nascens* (542), *predisposing affinity* (548), etc. And the compounds of nitrogen, when formed, are generally unstable, decomposing readily, and sometimes with explosive violence. Heat is often sufficient to cause their decomposition. Hence, nitrates are effective oxidizing agents, and our most powerful explosives are nitrogen compounds. The nitrogenous substances in animal matter decompose rapidly. It is clearly

these very properties of nitrogen which render nitrogenous matters suitable materials for the construction of certain animal tissues, nitrogen acting largely as a carrier of other elements and radicals.

[A remarkable exception to the generally unstable character of nitrogen compounds is the peculiar compound formed of boron and nitrogen, BN.]

714. The polyvalence and indifferent chemical energy of nitrogen are its ruling characteristics. By reason of these characteristics it forms, both with oxygen and with hydrogen, powerful compound radicals, in the formation of which the nitrogen must be regarded as a passive agent. In forming compound radicals with oxygen the nitrogen is electro-positive, with hydrogen electro-negative.

The strongest compound radicals are formed by quinquivalent nitrogen, as might be expected. Ammonium, NH_4, and nitryl, NO_2, are examples. But even trivalent nitrogen forms strong radicals, as, for instance, cyanogen CN.

715. The compounds formed by nitrogen with other non-metallic elements are singularly interesting.

716. It does not unite directly with any metal. We have seen that with oxygen it forms no less than five different *oxides;* but the radical NO_2 which combines with itself to form N_2O_4, and with OH to form *nitric acid,* and which enters into numerous organic molecules possessing striking properties, is the most remarkable group of N and O.

717. With hydrogen it forms the extraordinary substance which is so familiar to us under the name of *ammonia.* In this compound the nitrogen is the electro-negative radical, as we have stated. Ammonia unites directly with the acids, forming ammonium salts, the valence of the nitrogen rising at the same time from 3 to 5. A saturated compound of hydrogen with quinquivalent nitrogen (NH_5) does not exist. But NH_4, NH_2 and NH exist as powerful radicals.

Ammonia should be written H_3N instead of NH_3, the hydrogen being the positive radical of the molecule. It is not nitrogen hydride, but hydrogen nitride. The *alkaloids,* which in small quantities are such valuable medicines and in larger quantities frequently so deadly in their effects upon man and animals, are derivatives (843) of ammonia, retaining the nitrogen.

718. With sulphur nitrogen forms no stable compound, but only a violently explosive substance (N_2S_2).

With the halogens, also, nitrogen produces only extremely unstable molecules.

719. With carbon nitrogen forms a very remarkable compound radical called *cyanogen*, which is capable of combining with itself as well as with other radicals. In its chemical relations this compound radical conducts itself like the halogens, forming cyanides with the metals and other positive radicals. Cynanogen is extremely poisonous, the acid it forms with hydrogen (HCN), called *hydrocyanic acid* (formerly called *prussic acid*), is also a terrible poison, and so are several of the other cyanides.

720. Ammonia is prepared by double decomposition between calcium oxide ("quick-lime") and ammonium chloride: $2NH_4Cl + CaO = CaCl_2 + H_2O + 2H_3N$.

H_3N is a colorless gas having an extremely pungent odor, highly caustic and poisonous when inhaled, and affecting the eyes and air passages so strongly that solutions of ammonia (called "water of ammonia") must be handled with caution. One liter of the gas weighs 0.762 Grams. The Pharmacopœia contains one solution of ammonia containing 28 per cent. of H_3N, and another containing 10 per cent. When H_3N is dissolved in water, the solution may be properly regarded as containing ammonium hydrate: $H_3N + H_2O = NH_4OH$.

Ammonia water is largely employed in pharmaceutical chemistry as a convenient and effective alkali hydrate (874) for the precipitation of metallic hydrates, the neutralization of acids, etc.

721. Nitric Acid is prepared from potassium or sodium nitrate by the action of sulphuric acid: $NaNO_3 + H_2SO_4 = HNO_3 + NaHSO_4$. It is a highly corrosive acid and extremely poisonous because of its destructive chemical action.

The official nitric acid is a solution containing 69.4 per cent. of HNO_3 and having the sp. w. 1.42 (water=1.).

This acid is used to dissolve metals (890) and as an oxidizing agent.

722. Phosphorus and other polyvalent perissads.—Nitrogen, phosphorus, vanadium, arsenic, antimony and bismuth are generally placed together in one group, called the *nitrogen group*, because these elements all exhibit the same valence and many parallel compounds.

More than this, it is found that the members of this group disclose the same mutual relationship in their respective atomic weights as the members of the group of dyad salt-formers, the group of monad salt formers, and certain other natural groups of elements.

723. The nitrogen group (which is also sometimes called the "antimony group") is as follows :

Elements.	*Atomic Weight.*
Nitrogen,	14.
Phosphorus,	31.
Vanadium,	51.
Arsenic,	75.
Antimony,	120.
Bismuth,	209.

All are preferably triads and pentads ; but the closest relationship exists between phosphorus, arsenic and antimony, which from a sub group corresponding to the sulphur group (sulphur, selenium and tellurium) and the chlorine group (chlorine, bromine and iodine). The atomic weight of arsenic is very nearly one-half of the sum of the atomic weights of phosphorus and antimony.

724. Phosphorus is widely and generally distributed throughout the material world, but only in small quantities. The waxy or ordinary phosphorus has an extra-ordinary affinity for oxygen, with which it unites even at common temperatures, igniting when exposed to the air, and burning violently. It also burns in chlorine and bromine. [Red or amorphous phosphorus, however, is comparatively indifferent as to combining energy.] The acid-radicals of phosphorus are the most important; but it may also form basic compound radicals.

725. Arsenic and antimony stand in their relations to nitrogen and phosphorus, as selenium and tellurium to oxygen and sulphur. But arsenic, antimony and bismuth have marked metallic properties, and bismuth has a number of salts in which it acts as a positive radical, while arsenic and antimony have not.

726. The gradual changes of the members of the nitrogen group from nitrogen to bismuth are interesting. To show their similarities and divergencies, the following table will suffice:

$N.$	$P.$	$As.$	$Sb.$	$Bi.$
NH_3	PH_3	AsH_3	SbH_3	......
NCl_3	PCl_3	$AsCl_3$	$SbCl_3$	$BiCl_3$
......	PCl_5	......	$SbCl_5$	......
N_2O_3	P_2O_3	As_2O_3	Sb_2S_3	Bi_2O_3
N_2O_5	P_2O_5	As_2O_5	Sb_2S_5	Bi_2O_5
NH_4Br	PH_4Br	......	......	......
HNO_3	HPO_3	......	$HSbO_3$	$HBiO_3$
......	H_3PO_3	H_3AsO_3	......	......
......	H_3PO_4	H_3AsO_4	H_3SbO_4	......
......	......	As_2S_3	Sb_2S_3	Bi_2S_3
......	......	As_2S_5	Sb_2S_5	......

Vanadium is a rare metal.

727. Phosphorus (P; at. w. 31) is a soft, waxy, semi-translucent, nearly colorless or slightly yellowish solid, of peculiar odor and taste. It is of crystalline structure, luminous in the dark, poisonous. It melts at 44.° C., and boils at 290.° C. Insoluble in water and sparingly soluble in alcohol; but soluble in chloroform and carbon disulphide; in fixed oil it is soluble to the extent of 1 per cent.

It has such strong affinity for oxygen that if allowed to come in contact with air it ignites and burns fiercely, forming phosphorus pentoxide, which is a snowy white solid and which forms phosphoric acid when brought in contact with water. Phosphorus must, therefore, be kept under water, and be handled with great caution.

Phosphorus occurs combined with calcium through oxygen in the calcium phosphate of bones.

728. *Preparation.*—The normal, ordinary, or yellow phosphorus is made from calcined bone, which is heated with charcoal in retorts, the P_4 distilling over: $3Ca(PO_3)_2+5C_2=P_4+Ca_3(PO_4)_2+10CO$.

729. Red phosphorus is formed when the ordinary phosphorus is heated to 300° C., excluded from the air, as in CO_2.

It is called amorphous phosphorus, does not oxidize in the air, is not luminous in the dark, is insoluble in carbon disulphide, is infusible and non-poisonous.

730. P forms two oxides: trioxide, P_2O_3, and pentoxide, P_2O_5. The *acids* of P are:

Hypophosphorous acid=H_3PO_2.

Phosphorous acid=H_3PO_3.

Phosphoric acid=H_3PO_4.

Metaphosphoric acid=HPO_3.

Pyrophosphoric acid=$H_4P_2O_7$.

Their salts are called hypophosphites (918), phosphites, orthophosphates (914), metaphosphates (916), and pyrophosphates (917).

731. Phosphoric Acid.—The ordinary phosphoric acid, H_3PO_4, is orthophosphoric acid, and the Pharmacopœia contains a 50 per cent. solution called "Phosphoric Acid," and a 10 per cent. solution called "Diluted Phosphoric Acid."

It is most frequently prepared by oxidizing phosphorus by means of nitric acid. The phosphorus is placed in nitric acid of suitable strength; when the reaction is completed the product is freed from arsenic (derived from the usually impure phosphorus), and from other impurities, and diluted to the required strength.

The reaction is: $P_4+4HNO_3+2H_2O=4H_3PO_3+2N_2O_2$; and finally $3H_3PO_3+2HNO_3=3H_3PO_4+N_2O_2+H_2O$.

732. Phosphine, H_3P, or "phosphoretted hydrogen," or hydrogen phosphide, is made by heating P_4 in a solution of KOH or NaOH. It is an inflammable, poisonous gas, of a disagreeable garlicky odor.

733. Arsenic (As; at. w. 75) is a dark steel-gray crystalline, heavy solid of a dull metallic lustre. It is volatile, distilling without first melting, the vapors having a yellowish brown color and garlicky odor. But in the solid state arsenic is odorless and tasteless. Insoluble in all neutral solvents.

It occurs mostly in combination with S. Compounds of As are white, yellow or red. They are made from the metal or its oxide.

734. Arsenic has two *oxides*, namely a trioxide or arsenous anhydride, As_2O_3, and a pentoxide, or arsenic anhydride, As_2O_5.

The ordinary "white arsenic," which the Pharmacopœia calls "arsenious acid," is arsenous oxide. As is well known, it is poisonous.

735. With H arsenic forms a gaseous compound called "arseniuretted hydrogen;" it is hydrogen arsenide, or H_3As, and is also called *arsine*. Hydrogen arsenide has a garlicky odor, and is very poisonous.

736. Sulphides and chlorides of arsenic also exist, and an iodide of arsenic is contained in the Pharmacopœia. Among the official preparations of As are solutions of potassium arsenite, sodium arsenate and arsenous acid; the solution of sodium arsenate is made of 1 part of the anhydrous salt to 99 parts of water, and the others of one per cent. arsenous anhydride.

737. Antimony (Sb; at. w. 120) is a heavy, bluish-white, crystalline solid of decidedly metallic lustre. Melts at 425° C., and vaporizes at white heat. It occurs as "black sulphide of antimony," or antimonous sulphide, Sb_2S_3.

Nitric acid does not dissolve antimony but oxidizes it, the oxide of antimony thus formed being insoluble in nitric acid.

Compounds of antimony are white, black, yellow or red. They are prepared from the sulphide or the oxide.

738. The *oxides* of antimony correspond to those of arsenic. The pharmacopœial oxide of antimony is the antimonous oxide Sb_2O_3, which is a white powder, insoluble in water. Antimonic anhydride is Sb_2O_5. There is also an antimonate of antimonyl, $SbOSbO_3$.

739. With S, antimony forms antimonous sulphide, which is black when in crystalline form, or orange red when precipitated; and antimonic sulphide, Sb_2S_5, which is also orange red Sulphur salts of antimony exist, as, for example, the sulphantimonate of sodium, Na_3SbS_4, and sulphantimonite of sodium, Na_3SbS_3.

740. With Cl antimony forms $SbCl_3$ and $SbCl_5$. The trichloride is official in some pharmacopœias in the form of a solution; that "solution of chloride of antimony" must necessarily contain a considerable quantity of hydrochloric acid, for the $SbCl_3$ is not soluble in water but instead decomposed by it, while it is soluble in a mixture of water and HCl.

741. Potassium-antimonyl tartrate ($KSbOC_4H_4O_6$) is commonly called *tartar emetic*, and its official title is "tartrate of antimony and potassium." It is the only water-soluble antimony preparation in the pharmacopœias.

742. **Bismuth** (Bi; at. w. 208.9) is a heavy crystalline solid of reddish-white color; melts at 267° C., and vaporizes at white heat. It occurs in nature uncombined. Nitric acid dissolves bismuth to form the normal nitrate, $Bi(NO_3)_3$, which is soluble in a mixture of nitric acid and water, but decomposed by water alone.

The compounds of bismuth are white, black, red or colorless. They are made from the metal.

743. The *oxides* of Bismuth are Bi_2O_3 and Bi_2O_5. Chlorides and sulphides also exist.

The normal bismuth nitrate, $Bi(NO_3)_3$ being soluble in glycerin, is sometimes used as the material out of which other bismuth compounds are made. "Citrate of bismuth and ammonium" is the only water-soluble preparation of bismuth known to pharmacy.

The so-called "subnitrate of bismuth" and "subcarbonate of bismuth" of the Pharmacopœia are not bismuth salts but bismuthyl salts ($BiONO_3$ and $(BiO)_2CO_3$). When a solution of normal bismuth nitrate in water and nitric acid is poured into water, the salt is decomposed and bismuthyl nitrate produced.

744. **Boron** (B; at. w. 11) is an altogether unique element. It is, in the free state, a solid. Its most familiar compounds are *borax* and *boric acid* (formerly called "boracic acid").

Borax is sodium pyroborate, $Na_2B_4O_7.10H_2O$; boric acid is H_3BO_3.

Although B is a trivalent element, it possesses some analogies to silicon.

CHAPTER XXXV.

THE CARBON GROUP.

745. This group embraces carbon, silicon, titanium and tin, all of which are quadrivalent.

746. Carbon (C; at. w. 12) occurs in nature in the free state as diamond, graphite and coal. It exists only as a solid, and can be neither fused nor vaporized.

Diamond is the hardest substance known, and possesses unsurpassed lustre and brilliancy. It crystallizes in various forms of the Regular System.

Graphite is the so-called "plumbago," or the "black lead" of lead pencils, stove polish, etc.

Coal—hard and soft—consists mainly of carbon, and *charcoal* is also carbon; soot, lamp-black, "bone-black" and coke are also different forms of more or less impure carbon.

The specific weight varies according to the form, or *allotropic modication* as distinctly different forms of any one element are called.

Carbon is one of the most commonly occurring and abundant of the elements. It is the most important element in organic chemistry.

747. At common temperatures carbon exhibits no chemical affinity whatever for other substances. At a very high heat it readily unites with oxygen, forming two different oxides, one of which is an acid-forming oxide, CO_2; carbonic acid is, however, a very weak acid. But its lower oxide, CO, figures as a most important compound radical, called carbonyl, and may also be said to form carbonic acid by uniting with $(HO)_2$.

Carbon combines with hydrogen in numerous compounds, and forms with that element many compound radicals.

Its compounds with sulphur are analogous to those it forms with oxygen. Carbon disulphide, CS_2, is an ill-smelling liquid.

It also combines with the halogens.

With nitrogen it forms the important radical cyanogen which has already been referred to (719).

748. Carbon has *apparently* a variable valence as indicated by its oxides CO and CO_2. But its other compounds show that its ruling valence is that of a tetrad. The most striking function of carbon is its passive agency in the formation of compound radicals. In this respect it occupies among the artiads a position analogous to that of nitrogen among the perissads.

749. *Organic Chemistry* is defined sometimes as " the chemistry of the carbon compounds." It is also defined as "the chemistry of the hydrocarbons and their derivatives."

If the molecular formulas of inorganic compounds be placed beside the molecular formulas of organic compounds, and the two series compared, the organic molecules seem very complex and the inorganic molecules comparatively simple. The differences in structure are, indeed, in numerous cases so great that the student might easily draw the erroneous conclusion that organic chemistry must be governed by laws wholly different from the laws of inorganic chemistry. But the chemistry of the rose and ruby, the air and the bird, gold and the apple, calomel and quinine, stone and bread, must be subject to the same laws. Inorganic chemistry and organic chemistry are not merely near relatives, of whom we might know one intimately, while having barely a speaking acquaintance with the other ; they are not as two persons, but as the different parts of one man.

750. The apparent complexity of organic chemistry is the natural result of the high valence of carbon, the power of the carbon atoms to combine with each other, the stability of the carbon bonds, the ability of carbon to combine with other elements of the most dissimilar nature, the behavior of carbon toward hydrogen and oxygen with which it forms many compound radicals, etc.

751. The position of carbon in the first series of elements arranged according to their atomic weights (664) is not only the central position, but the elements on both sides of it are the first members of important natural groups, thus :

$$\text{I} \quad \text{II} \quad \text{III} \quad \text{IV} \quad \text{III} \quad \text{II} \quad \text{I}$$
$$\text{Li (7), Be (9), B (11), C (12), N (14), O (16), F (19).}$$

The valence of these elements, beginning with lithium, increases regularly from one to four (C), and then decreases as regularly toward the other end of the series.

752. Carbon, being quadrivalent, has four bonds. Each of its four valence units may be satisfied by a different radical.

Carbon atoms may combine with each other in three possible different ways, as follows:

$$-C\equiv C-, \qquad \overset{|}{\underset{|}{C}}=\overset{|}{\underset{|}{C}}, \qquad \text{or} \qquad -\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$$
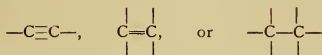
Thus two carbon atoms united to each other may present together either two, four or six free bonds. A greater number of carbon atoms must produce still greater variety.

753. Other polyvalent elements may, in a similar manner, though not to the same extent, be capable of forming different chains, etc. (831), and as both nitrogen, oxygen and sulphur combine with carbon, directly and indirectly, the possible combinations would appear to be without limit. Two nitrogen atoms may give us $-N\equiv N-$ or $=N-N=$, and three nitrogen atoms $=N-N-N=$, or $-N=N-N=$, etc. But oxygen atoms combining with each other can only form simple chains with two free bonds, and sulphur atoms likewise.

754. Add to these possible combinations the further fact that not only univalent atoms, as those of hydrogen or of chlorine, may unite with the free bonds presented by the chains or clusters of carbon atoms, but that compound radicals may be united to these free bonds, and, finally, polyvalent radicals, elemental or compound, may link the carbon chain or cluster to still other radicals, as, for example, in:

Paraldehyde.
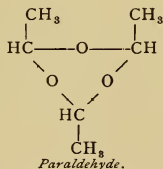
755. *The Oxides of Carbon.*—When carbon undergoes combustion in a limited supply of O_2 or of air, the product of the reaction is CO, or carbon monoxide, or carbonous oxide. This is a colorless, odorless, tasteless gas, which burns with a blue flame to CO_2. Carbon monoxide is poisonous when inhaled.

The higher oxide is formed when carbon is burned in a free supply of O_2, and is also produced by the decomposition of carbonates by the stronger acids, because carbonic acid, H_2CO_3, at once splits up into CO_2 and H_2O. Carbon dioxide is also called

carbonic oxide and "carbonic acid gas." It is colorless, slightly pungent, of a refreshing, faintly acidulous taste, soluble in water. At ordinary temperatures and pressure it dissolves in an equal volume of water; but with the aid of cold and strong pressure much larger quantities of CO_2 can be forced into a state of solution in water, and such a solution is called "carbonic acid water." When inhaled the CO_2 acts as a poison, and a comparatively small proportion of CO_2 in the atmosphere of a room is sufficient to render it unhealthy.

756. **Silicon** (Si; at. w. 28.3), which is so abundant in the silicates of the earth's crust, as in quartz rock and sand, is analogous to carbon in the structure of its compounds. It is of the greatest importance in its geological relations.

Glass is composed of silicates of sodium, potassium, calcium and lead; glass containing the silicates of K and Ca is *hard* and not easily fused, while *flint* glass made of the silicates of K and Pb is more readily fusible and brilliant, and *soft* glass made of the silicates of Na and Ca fuses very readily.

757. **Tin** (Sn; at. w. 119) is also industrially important, although not very abundant. Notwithstanding its decidedly metallic physical properties it presents many points of resemblance to carbon in its chemical compounds. It is a silver-white metal, soft, ductile, of crystalline structure, melting point 228° C., vaporizable at white heat. It does not oxidize on exposure to air, and is, therefore, used to coat iron ware. Tin also enters into several very useful alloys.

This metal occurs in nature as stannic oxide, called "tin-stone," or "tin ore." Compounds of tin are mostly white or colorless, and are made from the metal or its chloride.

758. "Tin salt" is chloride of tin, $SnCl_2$, and is used as a mordant in dyeing. It is soluble in water mixed with hydrocloric acid.

759. *Titanium* is also chemically a relative of carbon, but it is so rare an element that it will not be described here.

760. The carbon group and the nitrogen group, side by side, show some interesting parallels:

Negative Tetrads.		Negative Polyvalent Perissads.	
	Atomic Weight.	*Atomic Weight.*	
Carbon	12	14	.... ,Nitrogen
Silicon............................	28.3	31	....Phosphorus
Titanium.............	48	51	....Vanadium
....		75	. ... .Arsenic
Tin	119	120	....Antimony
....		209	....Bismuth

CHAPTER XXXVI.

SUMMARY.

761. The electro-negative monads and dyads are salt-formers. They are active agents in producing compound radicals, which they do by saturating only a portion of the valence units of the trivalent and quadrivalent electro-negative elements.

Oxygen and hydrogen are of the greatest importance in the relations between other elements and their most numerous compounds. While these two elements are the principal active agents in forming compound radicals, they are opposite to each other, in this respect: Oxygen characterizes the negative compound radicals, while hydrogen characterizes the positive compound radicals.

The electro-negative, trivalent and quadrivalent elements are not salt-formers; they are passive agents in the formation of compound radicals, and act as links, centers, and skeletons, by which radicals are united into molecules.

CHAPTER XXXVII.

THE LIGHT METALS.

762. The invariably electro-positive elements are all metals. These have been classified in various ways.

Thus they have been divided into two groups: *light metals*, whose specific weights are less than 5, and lower than the specific weights of their oxides; and *heavy metals*, whose specific weights are over 5, and higher than the specific weights of their oxides.

They have also been classified into: alkali metals; alkaline earth metals; earth metals, proper; etc.

The several methods of classification adopted by different chemists must necessarily coincide in many places as they are all based upon natural relationships.

763. We may first place the five strongest electro-positive metallic radicals together, in the order of their atomic weights:

	Atomic Weights.
Lithium	7.
Sodium	23.
Potassium	39.
Rubidium	85.2
Cæsium	132.7

All these metals are monads. It will be observed that the atomic weight of sodium is exactly one-half of the sum of the atomic weights of lithium and potassium, and that of rubidium is almost exactly one-half of the sum of the atomic weights of potassium and cæsium, a pretty regular gradation is apparent in the atomic weights of the whole group, and these five metals are the strongest electro-positive radicals known, from cæsium to lithium, in just the order in which their atomic weights place them; cæsium being the strongest, and lithium the least pronounced alkali metal.

764. As this group includes all of the alkali metals, the table becomes all the more significant. Still greater emphasis will be given to this exhibit if we place opposite the alkali metals all dyad metals having nearly coincident atomic weights:

Dyads.	Monads.
Atomic Weights.	*Atomic Weights.*
Glucinum...................... .... 9.	7. .... Lithium
Magnesium...................... 24.	23. .. .. .Sodium
Calcium........................ 40.	39. .... Potassium
Strontium...................... 87 3	85.2...................Rubidium
Barium.......................: .137.	132.7....... ....Cæsium

These five dyad metals stand next after the alkali metals in the electro-chemical series in precisely the order in which they stand in the preceding table, beginning with barium and ending with glucinum.

All of the ten metals included in the table are *light metals*, and all the "light metals" (762) are included except Aluminum (with the atomic weight 27) and the rare metals Yttrium (At. wt. 89), Zirconium (At. wt. 90.4), Lanthanum (At. wt. 138), Cerium (At. wt. 140), Didymium (At. wt. 142 now split up into two elements), Erbium (At. wt. 166) and Thorium (At. wt. 232), which are not so well known.

765. **The alkali metals,** then, are all monads, and have low specific weights; their hydrates, or compounds with HO, are the true alkalies, which are very readily water soluble (with the exception of lithium hydrate which is not readily soluble); their normal carbonates and phosphates are also freely water soluble (except those of lithium, which are rather sparingly soluble). Their carbonates and hydrates are not decomposed by heat. Their normal salts have either an alkaline or a neutral reaction on test paper.

766. The alkali metals have such intense chemical affinity for oxygen that they must be kept immersed in naphtha. They even decompose water, appropriating the oxygen so that the hydrogen is liberated. Cæsium decomposes water with great violence; lithium more quietly. These metals also have an intense affinity for the halogens and sulphur. Observe that the alkali metals decompose water by taking to themselves its oxygen, while chlorine decomposes water by uniting with the hydrogen.

Potassium oxide is K_2O. It reacts with water so violently that flame results. The oxides of the alkali metals form hydrates when they come in contact with water.

767. **Potassium** (K; at. w. 39) exists in nature only in compounds. In minerals as silicate; in the salt deposits at Stassfurth, Germany, it is contained in the form of chloride; and the ashes of plants contain potassium carbonate. The juice of grapes contains acid tartrate of potassium, which deposits on the bottom and sides of wine vats and casks in the form called *argols* or *crude tartar*, which, when freed from coloring matter and other impurities, furnishes *cream of tartar*.

768. Potassium is a soft bluish white metal which oxidizes rapidly when exposed to the air, and decomposes water, from which it appropriates the oxygen. It is produced by strongly heating K_2CO_3 with C_2, the reduced metal being distilled over. To protect the metallic potassium from oxidation it is kept in some liquid hydrocarbon, as in petroleum.

769. The potassium compounds are, as a rule, colorless or white. They are either alkaline or salty to the taste. They are frequently anhydrous, generally water-soluble, and the hydrate, carbonate and acetate are deliquescent. Of the common potassium compounds of the drug store the least soluble are the acid tartrate or cream of tartar, the sulphate, chlorate, and permanganate.

770. The materials employed for making potassium preparations are first the crude chloride from Stassfurth, then the carbonate made from that chloride, and the bicarbonate. The pharmacopœias prefer the bicarbonate as the material from which to prepare the other potassium compounds, because the bicarbonate is crystallized and generally sufficiently pure as well as cheap.

The most common potassium compounds are the hydrate, carbonate, bicarbonate, bromide, iodide, nitrate, chlorate, permanganate, acetate, citrate, tartrate and bitartrate, all of which are described in the Pharmacopœia. A solution of potassium hydrate, called "liquor potassæ" is also official.

Potassium hydrate, KOH ("potassa"), is extremely caustic and corrosive, and, therefore, poisonous. Even the carbonate ("potash," or "pearl-ash," or "salt of tartar") is destructive and poisonous when introduced into the body without sufficient previous dilution or in too large quantities. The best antidotes are vinegar, lemon juice, citric acid, olive oil, cotton seed oil, milk, etc.

"Saltpetre" is potassium nitrate.

771. Sodium (Na; at. w. 23) occurs most commonly as chloride of sodium, which constitutes "salt." From this the carbonate ("sal sodæ") is manufactured on a large scale.

It is a soft, silver-white metal which, like potassium, must be kept in hydrocarbons to keep it from oxidizing, and it is produced from sodium carbonate by a process analogous to that by which K_2 is made.

772. Compounds of sodium are, as a rule, white or colorless, and water-soluble. Their taste is either alkaline or purely salty, or bitterish. Water of crystallization occurs more commonly in sodium salts than in the salts of potassium, and many of the crystallized sodium salts effloresce when exposed.

773. Sodium preparations are made from the carbonate which is both cheap and generally sufficiently pure, being crystallized.

The most commonly used sodium compounds are the hydrate, carbonate, bicarbonate, chloride, bromide, nitrate, sulphate, phosphate, acetate, salicylate, and the tartrate of potassium and sodium. There is also an official solution of the hydrate, NaOH.

Sodium hydrate is called "soda" by the Pharmacopœia; "washing soda" is the crystallized sodium carbonate; and "baking soda" is the bicarbonate. The sulphate is sometimes called "Glauber's salt," and the tartrate of potassium and sodium is "Rochelle salt."

774. Lithium (Li; at. w. 7) is a comparatively rare metal, and its compounds, therefore, expensive.

The most common compounds are the carbonate, bromide, chloride, citrate and salicylate. They are all white, and prepared from the carbonate derived from the mineral *lepidolite*.

775. Ammonium is NH_4, a positive compound radical which forms salts in many respects closely resembling those of K, Na, and Li. It indeed behaves as if it were a compound alkali metal.

Ammonia, or hydrogen nitride, H_3N, is contained in the *gas liquor* obtained in the manufacture of illuminating gas, and, when purified, this ammonia is now the chief material used for the production of the ammonium compounds.

Ammonium compounds are white or colorless, and water-soluble. All are odorless except the hydrate and the carbon-ate, which have the strong odor of ammonia; all ammonium compounds develop the odor of ammonia on the addition of potassium hydrate or sodium hydrate. Their taste is alkaline, or salty ; sometimes bitterish.

The most common ammonium compounds are the hydrate, carbonate, chloride, bromide, nitrate and acetate. Ammonium hydrate is contained in the "water of ammonia" of the pharma-copœias ; it is sometimes called "caustic ammonia," and also "spirit of hartshorn." The "carbonate of ammonium" of the Pharmacopœia is a complex substance containing carbamate as well as carbonate ; this mixed salt is sometimes called "salt of hartshorn," and also "sal volatile." Ammonium chloride is often called "muriate of ammonia," and also "sal ammoniac."

776. The alkaline earth metals are calcium, strontium and barium.

They are dyads, and have low specific weights.

Like the alkali metals they have such an intense affinity for oxygen that they decompose water.

Their oxides, however, can be kept and do not react with water so violently as do the oxides of the alkali metals.

Their hydrates are only sparingly soluble in water, and their normal carbonates as well as their phosphates are insoluble, while their acid carbonates are water-soluble to a small extent. Their normal salts, as far as water-soluble, have a neutral reaction on test paper. The sulphides are water-soluble. The sulphates and oxalates are insoluble.

By reference to the comparative exhibit on page 197 it will be seen that the atomic weight of strontium is very nearly one-half of the sum of the atomic weights of calcium and barium. Barium is the strongest electro-positive dyad, strontium the second; and calcium, the third

777. Calcium (Ca; at. w. 40) occurs abundantly in the form of lime-stone and other calcium compounds.

The metal is light-yellowish.

" Chalk " and " marble " are calcium carbonate, and "lime " (" quick-lime ") is calcium oxide, while "slaked lime " is calcium hydrate.

The most abundant and convenient materials for preparing calcium compounds are the carbonate and the chloride. The chloride, which is freely soluble in water, is made by saturating hydrochloric acid with calcium carbonate; the many insoluble calcium compounds are made by precipitation from the chloride.

The oxide (" lime ") has the name " calx " in Latin and the words calcium and calcination are derived from it. When common lime-stone (impure calcium carbonate) is strongly heated in the "lime-kiln," it is said to be *calcined*, the carbonate being decomposed into oxide and CO_2:

$CaCO_3 = CaO + CO_2$.

When the lime or calcium oxide is put into water, or when water is added to the lime, calcium hydrate is formed:

$CaO + H_2O = Ca(OH)_2$.
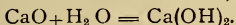
The lime water of the drug stores, then, is solution of calcium hydrate.

The most common calcium compounds not already named are the precipitated calcium carbonate, prepared chalk, dried sulphate of calcium, and the phosphate of calcium.

" Plaster of paris " is the dried sulphate of calcium, which when mixed with water unites with it chemically to form a hard crystalline solid.

" Bone-ash " is calcium phosphate from " calcined bones."

Preparations of calcium are white or colorless. The insoluble are tasteless; others have a disagreeable caustic or bitterish taste.

778. Strontium (Sr; at. w. 87.3) is of comparatively little importance to pharmacists; and even Barium (Ba; at. w. 137) is of minor interest.

The hydrates of Ca, Sr, and Ba are sparingly soluble in water their carbonates, phosphates, sulphates and oxalates insoluble.

779. The next group, naturally following those of the alkali metals and the alkaline earth metals, is **the zinc group**.

Glucinum (At. wt. 9) is often classed in this group, but as it is a rare metal we shall omit further mention of it.

The zinc group, then, consists of:

Atomic Weight.

Magnesium	24
Zinc	65
Cadmium	112

It will be seen that in this group, again, the atomic weight of the middle member is about one-half of the sum of the atomic weights of the other two; but in this case the metal having the lowest atomic weight is the strongest positive element and the metal having the largest atomic weight is the weakest. But all are strongly electro-positive radicals. They are dyads.

These metals do not exhibit so strong an affinity for oxygen as those before considered; they may even be freely exposed to the air without becoming oxidized. Their hydrates are not water-soluble; but zinc hydrate is soluble in solution of potassium hydrate or of ammonium hydrate. Their carbonates, phosphates and sulphides are insoluble; but the sulphates, soluble.

The carbonates of these metals, precipitated from the solutions of their water-soluble salts by alkali carbonates are not normal but basic (containing hydrate as well as carbonate); but normal magnesium carbonate can be prepared in other ways.

780. But we will take up zinc later and treat for the present of magnesium and aluminum, only, because zinc is decidedly one of the heavy metals.

The medicinal effects of the compounds of the light metals

are alkaline, antacid, laxative and cathartic, except so far only as other medicinal properties are imparted to them by the negative radicals they contain. They are poisonous only when corrosive or chemically destructive.

In this they differ from the compounds of the heavy metals, which, with the exception of the iron compounds, are poisonous, and all of which have more decided medicinal properties determined by their positive radicals.

781. Magnesium (Mg; at. w. 24.3) occurs as carbonate and silicate, and in spring waters as sulphate and chloride. Talcum and asbestos are magnesium silicate with carbonate.

The principal material used for the production of other magnesium compounds is the native carbonate. From this the sulphate may be made, and the sulphate is used for the production of purer carbonate and other compounds.

The metal is silver-white, can be ignited, and burns with a most intense light to magnesium oxide.

782. The compounds of magnesium are white or colorless, tasteless when insoluble, bitter when soluble, except the citrate. The most commonly used insoluble magnesium compounds are the oxide and carbonate; the soluble are the sulphate and citrate; chloride is much used in the manufacture of mineral waters.

Magnesium oxide is called "magnesia" by the Pharmacopœia, and is also frequently called "calcined magnesia," because it is made by heating the carbonate. The magnesium carbonate of the pharmacopœias is not the normal carbonate, but a compound of carbonate and hydrate. Sulphate of magnesium is commonly called "Epsom salt," because it is contained in the water of the Epsom Springs, England.

783. Aluminum (Al), a tetrad metal with the atomic weight 27, stands alone.

It is destined to be one of the most important of all metals in the near future, for it does not oxidize in air at any temperature, and dilute acids have scarcely any effect upon it, except hydrochloric acid.

Aluminic salts contain two atoms of aluminum tied together so that but six of the eight bonds are free to combine with other radicals (786).

The most common salt is "alum." All water-soluble aluminum compounds are astringents.

Sulphate, chloride, nitrate and acetate are water-soluble; hydrate and phosphate, insoluble; carbonate does not exist.

CHAPTER XXXVIII.

THE HEAVY METALS.

784. Zinc (Zn; at. w. 65.1) is a bluish-white metal of crystalline structure; sp. w. 7.2; melting point, 412° C.; volatilizes at about 1,000° C. It occurs as *calamine*, which consists of carbonate and silicate, and as *zinc blende*, which is sulphide.

The metal is obtained by reducing the ore with carbon at a high heat.

785. Zinc compounds are white or colorless, and when soluble they have a disagreeable, bitter, astringent, metallic taste, and are poisonous.

The materials used for the preparation of officinal zinc compounds are the metal, oxide, carbonate and sulphate. The sulphate is made by dissolving the metal in dilute sulphuric acid, the carbonate from the sulphate by precipitation with sodium carbonate, the oxide by calcining the carbonate, and the acetate as well as other soluble salts by saturating the proper acid with the oxide or carbonate.

786. The Iron Group.—This group is a peculiar one. Its members are:

	Atomic Weight.
Chromium,	52.
Manganese,	55.
Iron,	56.
Nickel,	58.6
Cobalt,	58.6

The atomic weights of all, it will be observed, are nearly the same. Like aluminum, these metals are pseudo-triads—that is, they form series of compounds in which two atoms of the metal are tied to each other and act together as one radical with six free bonds, thus:

$$\begin{matrix} | & | \\ -Al\!-\!Al\!- \\ | & | \end{matrix} \qquad\qquad \begin{matrix} | & | \\ -Fe\!-\!Fe\!- \\ | & | \end{matrix}$$

But while aluminum never acts as a dyad or a hexad, the metals of the iron group seem to have three separate valences, although nickel and cobalt do not exhibit decided evidences of sexivalence.

The metals of the iron group have two principal series of compounds—the *-ous* compounds, in which they act as dyads, and the *-ic* compounds, in which they act as tetrads, two atoms, tied together, acting each as a pseudo-triad.

For convenience, the metals themselves are distinguished by their own derived adjectives with the terminations *-ous* and *-ic* to specify their respective valence. Thus *ferrous iron* is a bivalent iron atom; ferric iron is two tetrad atoms tied together, and together acting as a pseudo-triad. In the same manner we speak of chromous chromium and chromic chromium; manganous manganese and manganic manganese; nickelous nickel and nickelic nickel; cobaltous cobalt and cobaltic cobalt.

These metals are slowly oxidized in air, and do not exhibit great chemical energy; and their compounds are not as stable as those of the metals before described. Their oxides, hydrates, phosphates and sulphides are insoluble. Their carbonates are so unstable as to begin to decompose rather rapidly as soon as they have been formed. Their nitrates, sulphates and haloids are readily water-soluble.

787. Iron (Fe; at. w. 56) is one of the most common and familiar of the metals. The best *iron ore* is the magnetic oxide of iron, or ferroso-ferric oxide. The metal is obtained from the ore by reduction with charcoal at high heat. There are three distinct forms of commercial iron—steel, cast iron, and wrought iron, differing in properties according to the amount of carbon they contain.

788. There are two classes of iron compounds—*ferrous compounds*, which contain ferrous iron (Fe) ; and *ferric compounds* containing ferric iron (Fe₂).

The *ferrous compounds* are generally green or greenish blue when they contain water, white or nearly white when dry.

The ferric compounds are reddish-brown, or yellowish-red when containing water, white or pale yellow when dry.

But some iron compounds have a lively blue color (as " Prussian Blue "), others a pure yellow color (as the oxalate), and other colors are represented by them.

Ferrous compounds are produced from metallic iron or from ferrous sulphate. Ferric compounds are made from ferric sulphate or chloride, or from ferric hydrate, or by changing the ferrous compounds to ferric by means of nitric acid or chlorine.

As iron dissolves readily in either hydrochloric or sulphuric acid, the ferrous chlorides and sulphates are easily made by saturating these acids with the metal.

The iron compounds used in medicine are numerous. When water-soluble they usually have a peculiar inky or styptic astringent taste, except the " scale salts " which are comparatively free from the disagreeably inky taste.

" Green vitriol " is ferrous sulphate.

" Tincture of Iron " contains ferric chloride.

789.   Lead (Pb ; at. w. 206.4) is also a common metal, comparatively soft, and of great density, melting at 325° C.

It occurs most commonly as *galena*, which is lead sulphide. The metal is obtained from this ore.

It is preferably a tetrad, but sometimes also acts as a dyad. Besides these variations in its valence it also has the oxide Pb₂O, in which it must be assumed that the two lead atoms are tied together. See Silver (797).

Lead does not oxidize except superficially in the air. It has greater affinity for sulphur than for oxygen. The carbonate of lead is a basic carbonate similar in composition to the carbonates of the metals of the zinc group.

Lead compounds are of various colors, some white, others colorless, others red, yellow or black. The nitrate and the acetate are the only water-soluble lead salts. They are poisonous, and even the insoluble lead compounds are poisonous because they slowly yield sufficient quantities of soluble lead compounds to produce the poisonous effects.

The nitrate and acetate serve as materials for the production of most of the other lead compounds.

791. Copper and Mercury.—These two metals are uniformly bivalent in their compounds. Their atomic weights are:

Atomic Weight.

Copper.. 63.2
Mercury.......... 200

They have been grouped in several different ways with other metals (793).

Notwithstanding their uniform valence, they have two series of compounds—the *-ous* compounds containing mercurous mercury (—Hg—Hg—) or cuprous copper (—Cu—Cu—), and the *-ic* compounds formed by mercuric mercury (—Hg—) and cupric copper (—Cu—).

The metals are not readily oxidized in air without the aid of heat. The oxides of copper are stable compounds; those of mercury readily decomposed by heat. The hydrates, phosphates and sulphides are insoluble. Normal carbonates do not exist; the basic carbonates are insoluble. Sulphate, nitrate and chloride of cupric copper are water-soluble. Cuprous salts are rare and unstable.

The only water-soluble mercury compounds are the mercuric chloride and mercuric cyanide. Nitrates of mercurous and mercuric mercury and mercuric sulphate are decomposed by water.

792. Copper (Cu; at. w. 63.2) is a reddish metal, harder than lead, but softer than iron; it does not become tarnished in dry air. It occurs in the free state in large quantities.

The only common copper compound used in pharmaceutical work and in medicine is the sulphate, which is a blue, crys-

tallized, water-soluble salt, often called *blue vitriol*. Other copper compounds are blue, green, brown, or black. All are poisonous.

793. **Mercury** (**Hg**; at. w. 200) is the only liquid metal. It is silver white, and is also called quicksilver. Sp. w. 13.6. Boils at 360° C. It occurs in the form of sulphide, or *cinnabar*.

All mercury compounds are more or less poisonous, and their poisonous character is as usual in the ratio of their solubility, the mercuric compounds being more dangerous than the mercurous. The metal itself, however, does not have a poisonous effect.

Mercury compounds are white, colorless, red, yellow, or black. Only mercuric chloride and mercuric cyanide are water-soluble. Mercury nitrates decompose on contact with water.

794. The materials used for making compounds of mercury are the metal itself and the mercuric chloride. The solution of nitrate of mercury in water containing nitric acid is also used. Sulphate of mercury is prepared by heating the metal with sulphuric acid, and the sulphate is then used for preparing calomel and corrosive sublimate, by double decomposition with sodium chloride, the mixture being subjected to sublimation.

795. Among the most important preparations of mercury are blue mass, blue ointment and mercury with chalk, all of which contain finely divided metallic mercury, and the official compounds of mercury include the red and yellow oxide, the chlorides and iodides, the mercuric sulphate and subsulphate and white precipitate.

"Calomel," or "mild chloride of mercury," is the mercurous chloride, Hg_2Cl_2.

"Corrosive sublimate," or "corrosive chloride of mercury," is mercuric chloride, $HgCl_2$.

"Red precipitate," or "red oxide of mercury," is mercuric oxide prepared by decomposing the nitrate by heat; it is not a precipitate. The "yellow oxide of mercury" is also mercuric

oxide made by precipitation resulting from double decompo-
sition between mercuric chloride and potassium hydrate.

"Green Iodide of mercury" is mercurous iodide; "red iodide
of mercury" is mercuric iodide.

"White precipitate" is mercur-ammonium chloride,

$$NH_2HgCl.$$
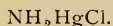
796. Silver (Ag; at. w. 107.7) is a beautiful white metal,
capable of receiving a high polish; soft, ductile, not tarnished in
pure, dry air.

It occurs free as well as in the form of sulphide.

The only silver compound much used is the nitrate which is
obtained by dissolving the metal in nitric acid, and the product is
either crystallized or fused and moulded into sticks or pencils.

Silver nitrate, when cast into cylindrical sticks, is often called
"lunar caustic."

Silver oxide is seldom used. It is a dark brown, insoluble
powder.

797. Silver is a metal which has been placed by many
chemists in the same group with potassium, sodium and lithium.
Others class it with lead and copper.

By reason of its specific heat and for other reasons it has been recog-
nized as a monad, and on that account assigned a place beside the alkali
metals. Its atomic weight is 107.7, which would place it between rubidium
and cæsium. Although silver exhibits but slight affinity for oxygen, it forms
one of the most powerful bases. Nevertheless, it is a metal of high specific
weight; not affected by air, oxygen, or water; and its compounds do not resemble
those of the alkali metals to such an extent as to justify its assignment to the
group of potassium, sodium and lithium.

Its oxides correspond perfectly with those of lead, and its only readily
water-soluble salt is the nitrate, while the acetate is slightly soluble; these
are the only water-soluble salts of lead, too.

798. It is interesting to note that the only other perissad metal which has
some compounds reminding us of the alkali metals is thallium, which also
exhibits some relationship to lead, has very nearly the same atomic weight as
lead, and is often placed together with lead in what is then called the lead
group, containing only these two metals. The properties of thallium and its
compounds have been described as intermediate between those of lead and the
alkali metals, and their compounds. The hydrate, carbonate and sulphate of
thallium are water-soluble.

799. Many chemists put gold, silver and the platinum group together; others put silver, copper and mercury together; others, again, place lead and platinum in the same group, gold and thallium in another, and copper and mercury in a third group.

All these facts prove that it is still extremely difficult to effect a classification so natural as to receive general acceptance.

The following exhibit of the atomic weights of artiad metals with their parallel perissads is suggestive:

ARTIADS.		PERISSADS.	
	Atomic Weight.	*Atomic Weight.*	
Palladium .... 107.		108.........	Silver
Platinum ....195.		197.... ....Gold	
Lead ....207.		204 .. ..Thallium	

In Mendeleeff's table (664), upon which much in this chapter is based, we find copper, silver and mercury together in one column, beside the alkali metals, where they naturally fall by reason of their atomic weights, and it is a remarkable fact that all of them have corresponding oxides, Ag_2O, Cu_2O and Hg_2O, like those of the alkali metals, K_2O, Na_2O and Li_2O. But gold, lead and thallium also have analogous oxides, Au_2O, Pb_2O and Tl_2O. ⤳

800. Gold appears to be generally a triad, but also sometimes a monad, having such compounds as $AuCl_3$ and $AuCl$, Au_2O_3 and Au_2O, etc. Its atomic weight is 196.7. It is one of the weakest of the metallic radicals, nearly all its compounds being very unstable. The metal itself is not affected by oxygen, sulphur or acids. The only reagent which will attack and dissolve gold is "aqua regia" or some other solution of free chlorine. Occurs in nature in the free state only.

(See also preceding paragraph.)

801. The Platinum Group.—The metals of this group occur in nature only in the free metallic state. They are:

	Atomic Weight.
Ruthenium	101.4
Rhodium	103.
Palladium	106.4
Osmium	190.3
Iridium	192.5
Platinum	194.3

By their atomic weights, therefore, they fall into two groups, three of

them having atomic weights of from 101.4 to 106.4, the others from 190.7 to 194 3. The specific weights correspond in the same ratio, the first three having the sp. w. 12 and the others 21. Relatively the greatest similarity exists between:

Platinum and palladium.
Iridium and rhodium.
Ruthenium and osmium.

Pt and Pd exhibit bivalence and quadrivalence; the others also sexivalence. But the ruling valence of Pt and Pd is 2, and that of Ru and Os, 6; while Ir and Rh occupy the middle ground,

No acids attack any of these metals; they are not directly affected by oxygen or sulphur, but free chlorine (in "aqua regia") attacks them. Their alloys, however, dissolve in the stronger acids. Soluble double salts are the least unstable compounds of the platinum metals; all their other compounds are extremely unstable.

CHAPTER XXXIX.

SUMMARY OF METALS.

802. The electro-positive elements, or metals, omitting very rare elements, may now be reviewed in a general way, with the following conclusions:

The alkali metals possess such energetic *affinity for oxygen* that they oxidize completely and even violently in either air or water. The alkaline earth metals do not oxidize in air as rapidly as the alkali metals, but still completely; and they decompose water, though with less violence than the alkali metals. No other metals oxidize perfectly in either air or water, at ordinary temperatures, and the direct affinity for oxygen is entirely absent in aluminum, silver, gold and the platinum metals.

The *oxides* of alkali metals react with water to form hydrates with such energy that they are instantly changed, and with evolution of great heat, if permitted to come in contact with moisture. The oxides of the alkaline earth metals may be kept in dry air, but are hydrated by water, though with far less rapidity and heat than the alkali oxides. The oxides of other metals are not readily or completely hydrated when brought in contact with water.

The *hydrates* of alkali metals are freely water-soluble, except the lithium hydrate. Lithium stands midway between the other alkali metals and the alkaline earth metals, the hydrates of which are very sparingly water-soluble.

The oxides and hydrates of all other metals are insoluble in water.

The only normal *carbonates* are those of the alkali metals, thallium and the alkaline earth metals ; but the carbonates of potassium and sodium are very freely soluble, those of lithium and thallium comparatively sparingly, and those of the alkaline earth metals insoluble in water. The carbonates of the metals of the zinc group and of lead are basic, and insoluble in water. All metallic carbonates, except those of the alkali metals, are decomposed by heat. Of many of the heavy metals, no carbonates exist.

The only water-soluble *phosphates* are those of potassium, sodium and ammonium—the same positive salt radicals which have soluble carbonates.

The only water-soluble metallic *sulphides* are those of the alkali metals and the alkaline earth metals.

Soluble *sulphates* are formed by the alkali metals, thallium, the zinc, aluminum and iron groups, and copper ; the sulphates of the alkaline earth metals and lead are insoluble, and that of mercury is decomposed by water.

All metallic *chlorides* are water-soluble, except those of silver, lead, thallium and mercurous mercury. Chloride of antimony is decomposed by water.

The metallic *nitrates* are all water-soluble, except those of mercury and bismuth, which are decomposed by water.

The *compounds* of the alkali metals are the most numerous and generally very stable or permanent ; they are also either neutral or of alkaline *reaction* to test paper. The salts of the alkaline earth metals are also comparatively stable, and usually of neutral reaction ; and next in order those of the metals of the zinc group. The salts of other metals are less permanent and frequently of acid reaction, and the compounds of mercury, silver, gold and platinum generally unstable and comparatively few.

CHAPTER XL.

COMPOUND RADICALS.

803. Atoms unite with other atoms either singly or in groups. When a chlorine atom unites with another chlorine atom to form a molecule of chlorine, or with a hydrogen atom to form a molecule of hydrogen chloride, commonly called hydrochloric acid, each of these atoms exercises active chemical energy or affinity in the creation of the molecule; and when zinc is dissolved in the solution of the hydrogen chloride the reaction which sets in produces molecules of zinc chloride and hydrogen, each chlorine atom passing from the molecule of hydrochloric acid to the new molecule of zinc chloride; from this molecule of zinc chloride the chlorine atoms can be transferred to still another molecule—that of silver chloride—by mixing a solution of the zinc chloride with a solution of silver nitrate. At the same time the silver which unites with the chlorine to form the silver chloride must part from the group of atoms with which it was combined in the silver nitrate and that group unites with the zinc which was robbed of its chlorine by the silver. In this last reaction, then, we have both single atoms and groups of atoms passing from one molecule to another.

Atoms of different kinds very commonly travel together in certain definite groups, the several atoms in such a group being united to each other while

some one of the atoms in the group still has one or more unsatisfied valence units or free bonds, by which the whole group may thus be united to some other atom or group of atoms.

Thus, all nitrates contain the group NO_3, consisting of one nitrogen atom and three oxygen atoms, and in that group one of the oxygen atoms must have one unsatisfied bond or valence unit left, for nitrogen acts here as a pentad and oxygen is always a dyad, so that three oxygen atoms have six valence units together. The group NO_3 is called the nitrate group or the nitrate radical, because all nitrates contain this characteristic group; every compound containing this group is a nitrate, and no compound is a nitrate that does not contain it. The nitrate group or nitrate radical united to a hydrogen atom makes nitric acid $= HNO_3$. If we place a piece of silver in the solution of nitric acid a reaction ensues, and that product of the reaction which remains in the liquid is the salt called silver nitrate $= AgNO_3$. The molecule of nitric acid, HNO_3, has, then, become transformed into the new molecule $AgNO_3$ by the exchange of an atom of hydrogen for one of silver; but the nitrate group has passed into the new molecule unaltered. Lead put in the solution of silver nitrate will take the nitrate radical away from the silver and cause the liberated silver atoms to form molecules of silver which separate from the liquid in the solid state as a blackish powder. The lead nitrate is $Pb(NO_3)_2$ because lead is a dyad or has two bonds or valence units, while, as we have seen, the nitrate radical has only one, and we must accordingly have two nitrate groups to satisfy one atom of lead. Copper placed in the solution of lead nitrate usurps the place of the lead producing copper nitrate $= Cu(NO_3)_2$, while lead is precipitated. From the copper nitrate the nitrate radical can in turn be transferred to iron nitrate by putting iron in the solution of the copper nitrate; the iron nitrate is $Fe(NO_3)_2$. Now we might mix the solution of iron nitrate with a solution of sodium carbonate, which would result in double decomposition (529), the products being iron carbonate and sodium nitrate $=$ $NaNO_3$. Thus, we have transferred the nitrate radical, NO_3, from molecule to molecule, uniting it successively to several different positive radicals.

There are many other compound radicals besides NO_3, and all can be transferred from one molecule to another.

804. Compound radicals are groups of atoms united to each other but having one or more unsatisfied valence units or free bonds.

They, therefore, act in the same manner as free atoms, being united by their free bonds to other radicals of opposite electro-chemical polarity.

Compound radicals have an invariable valence.

805. All oxysalts (900) contain compound radicals. The sulphates all contain the characteristic sulphate radical SO_4; all compounds containing the radical CO_3 are carbonates; no compound can be a phosphate unless it contain the radical PO_4; all chlorates contain the group ClO_3; and the group C_2O_4 distinguishes the oxalates.

806. The compound radicals as well as the elemental radicals may be divided into two great classes—*positive* and *negative* radicals. Compound radicals containing oxygen but no hydrogen are as a rule electro-negative; those containing hydrogen but no oxygen are as a rule electro-positive. But there are many negative compound radicals containing both oxygen and hydrogen together with carbon, and also many positive radicals containing the same elements.

807. Hydrogen and oxygen together form the very important compound radical HO, or OH, called *hydroxyl*. This radical combines with itself to form the so-called peroxide of hydrogen $= H_2O_2$. It unites with many of the metals to form *hydrates* or *hydroxides*, and with many different negative radicals to form acids; with one hydrogen atom and any number of groups of CH_2 the hydroxyl forms alcohols, and all alcohols contain HO.

It is, of course, univalent since the hydrogen atom has but one bond which ties only one of the two bonds of the oxygen atom, leaving one oxygen bond free.

808.   Nomenclature of the compound radicals. They have been given names with the termination –*yl*, as, for instance, hydroxyl, carbonyl, carboxyl, nitryl, nitrosyl, sulphuryl, phosphoryl, methyl, ethyl, amyl, glyceryl, phenyl, acetyl, bismuthyl, antimonyl, etc. But many compound radicals have names which are not in accordance with this system.

809. **Acid-forming radicals** are those which form acids when united to the radical hydroxyl, HO. The principal acid-forming radicals of inorganic chemistry are :

RADICAL.	ACID FORMED.	
Cl	$HO.Cl$	Hypochlorous
ClO	$HO.ClO$	Chlorous
ClO_2	$HO.ClO_2$	Chloric
ClO_3	$HO.ClO_3$	Perchloric
SO	$(HO)_2.SO$	Sulphurous
SO_2	$(HO)_2.SO_2$	Sulphuric
S_2O	$(HO)_2.S_2O$	Thiosulphuric
NO	$HO\ NO$	Nitrous
NO_2	$HO.NO_2$	Nitric
H_2PO	$HO.H_2PO$	Hypophosphorous
HPO	$(HO)_2.HPO$	Phosphorous
PO	$(HO)_3.PO$	Orthophosphoric
P_2O_3	$(HO)_4.P_2O_3$	Pyrophosphoric
PO_2	$HO.PO_2$	Metaphosphoric
HAsO	$(HO)_2HAsO$	Arsenous
AsO	$(HO)_3.AsO$	Arsenic
As_2O_3	$(HO)_4.As_2O_3$	Pyroarsenic
HSbO	$(HO)_2.HSbO$	Antimonous
SbO_2	$HO.SbO_2$	Metantimonic
B	$(HO)_3.B$	Boric
B_4O_5	$(HO)_2.B_4O_5$	Pyroboric
CO	$(HO)_2\ CO$	Carbonic
CO	$(HO)_2.(CO)_2$	Oxalic
CN	$HO.CN$	Cyanic
SiO	$(HO)_2.SiO$	Silicic
SnO	$(HO)_2.SnO$	Stannic
CrO_2	$(HO)_2.CrO_2$	Chromic
Cr_2O_5	$(HO)_2.Cr_2O_5$	Dichromic
Mn_2O_6	$(HO)_3.Mn_2O_6$	Permanganic

810. The principal **positive compound radicals** of inorganic chemistry are:

Ammonium,	NH_4.
Antimonyl,	SbO.
Bismuthyl,	BiO.
Mercur-ammonium,	$NH_2 Hg$.

Ammonium is the radical contained in all ammonium salts and other ammonium compounds. Antimonyl occurs in the so-called "tartrate of antimony and potassium;" bismuthyl, in so-called "subnitrate of bismuth;" and mercur-ammonium, in so-called "ammoniated mercury."

811. In *organic chemistry* the most important *compound radicals* of common occurrence or of special interest to pharmacists are the following:

Positive compound radicals:

NH_4	Ammonium
CH_3	Methyl
CH_2	Methene
CH	Methenyl
C_2H_5	Ethyl
C_5H_{11}	Amyl
C_6H_5	Phenyl
C_3H_5	Glyceryl
C_2H_3O	Acetyl ($CH_3.CO.$)

Negative compound radicals:

HO	Hydroxyl
CO	Carbonyl
NO	Nitrosyl
NO_2	Nitryl
CN	Cyanogen
CNS	Sulphocyanogen

812. In paragraph 809 the radicals which form acids with the radical HO are enumerated, and the formulas and names of the acids are placed opposite the corresponding radicals, respectively.

Thus you find that the radical which forms sulphuric acid by

uniting with hydroxyl HO, is SO_2 (sulphuryl), and the formula
for sulphuric acid is given as $(HO)_2.SO_2$. This is a very explicit
formula, showing that sulphuric acid consists of one group
of atoms represented by SO_2, and two groups such as are called
hydroxyl, HO. But for the sake of convenience the formula for
sulphuric acid is not written as above $(HO)_2SO_2$, but instead it
is written H_2SO_4. We will now explain this.

813. That SO_2 is a bivalent radical you can readily ascer-
tain for yourself when you know that in sulphuric acid and all
other sulphates the sulphur atom is a hexad. There must
accordingly be six sulphur bonds and four oxygen bonds in SO_2,
leaving two sulphur bonds free. These are each united to one
group of hydroxyl, thus:

$$
\begin{array}{c}
\text{O—H} \\
| \\
\text{O=S=O} \\
| \\
\text{O—H}
\end{array}
$$
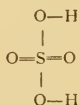
which may also be more briefly written:

$$SO_2 \diagup\!\!\diagdown \begin{array}{c}\text{OH}\\\text{OH}\end{array}$$

or still more briefly :

$$SO_2.(OH)_2 \text{ or } (OH)2.SO_2,$$

or finally:

$$H_2SO_4.$$
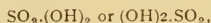
814. Whenever sulphuric acid forms a sulphate by com-
bining with any base, it is only the hydrogen of the groups of
hydroxyl that is exchanged, and one or both of the hydrogen
atoms may be replaced by another positive radical, as you will
see clearly by the following formulas:

H_2SO_4	Sulphuric Acid.
$KHSO_4$	Acid Potassium Sulphate.
K_2SO_4	Normal Potassium "
Na_2SO_4	Sodium Sulphate.
$CaSO_4$	Calcium "
$FeSO_4$	Ferrous "
$(NH_4)_2SO_4$	Ammonium Sulphate.

In other words, when sulphuric acid forms a sulphate with any base or metal, the hydrogen of the hydroxyl being replaced, the change would be most correctly represented as follows:

$$SO_2 \diagup O—H \qquad SO_2 \diagup O—K$$
$$\diagdown O—H \qquad\qquad \diagdown O—K$$

Sulphuric Acid.   Potassium Sulphate.

But for the sake of convenience, and since the linking oxygen atoms of the hydroxyl remain in their position, the general practice is to write the formula for every acid not by representing the radicals of which it is composed, but *the replaceable hydrogen is separated from and placed in front of the rest of the formula.* The remainder, after removing the hydrogen, is called an *acid residue.* Thus in H_2SO_4 the H_2 is all that is replaced by another base in the formation of other sulphates, and SO_4 is the *residue*, and, in fact, may well be treated as a radical, because the oxygen of the hydroxyl is still united to the SO_2, which makes it SO_4.

815. This is done, then, in writing the formulas of all acids. Although all acids contain hydroxyl, only the hydrogen of the hydroxyl can be displaced or replaced in the formation of salts, and that hydrogen is written first in the formula, the residue being placed after it and considered as the characteristic *acid radical.*

816. Acetic acid is composed of the three radicals, CH_3, CO and OH, and the structural formula (838) for the acetic acid molecule is therefore $CH_3.CO.OH$, but it is for convenience written $HC_2H_3O_2$, and sometimes it is written $C_2H_4O_2$. To write formulas in such a way that the number of replaceable hydrogen atoms can at once be seen is a very valuable point, however, and, therefore, we should always write the molecule of acetic acid as $HC_2H_3O_2$. As it has only one hydroxyl group it can have only one atom of basic hydrogen which can be replaced by any other positive radical; if the other hydrogen atoms or anyone of them should be removed, exchanged or replaced, the compound would no longer be an acetate.

817. It follows from what has been stated in the preceding paragraph that we have for every acid, inorganic or organic, an acid-radical which is shown in its molecular formula, and in the molecular formula of every salt (905). You can at once recognize any acid or a salt of any particular acid by its radical, if you learn what that radical is, and if you will learn not only the formula but also the valence of every such radical, together with the formula and valence of every positive radical of common occurrence, you will possess the knowledge necessary to construct the molecular formulas of all the normal compounds formed by these radicals respectively.

CHAPTER XLI.

TABLES OF RADICALS.

818. Tables are here given (819 and 820) of all the important and commonly occurring simple and compound radicals, positive as well as negative, grouped according to their valence, together with the generic name of the class of compounds formed by each when united to a radical of opposite electro-chemical polarity.

[In the next chapter we will explain how these tables can be used, and how formulas are constructed from the radicals according to their polarity and valence.]

819. Valence of Positive Radicals.

(BASYLOUS RADICALS.)

Univalent.	*Compounds formed.*
H	Acids
K	Potassium
Na	Sodium
Li	Lithium
Ag	Argentic
NH_4	Ammonium
CH_3	Methyl
C_2H_5	Ethyl

[BASYLOUS-RADICALS.—*Continued.*]

C_5H_{11}	Amyl
C_6H_5	Phenyl
NH_2Hg	Mercurammonium
BiO	Bismuthyl
SbO	Antimonyl

Bivalent.

Ca	Calcium
Ba	Barium
Sr	Strontium
Mg	Magnesium
Zn	Zinc
Cd	Cadmium
Pb	Plumbic
Cu	Cupric
Cu_2	Cuprous
Hg	Mercuric
Hg_2	Mercurous
Sn	Stannous
Mn	Manganous
Fe	Ferrous
Co	Cobaltous
Ni	Nickelous

Trivalent.

Sb	Antimonous
Bi	Bismuthous
C_3H_5	Glyceryl

Quadrivalent.

Sn	Stannic
Pt	Platinic

Sexivalent.

Ce_2	Cerium
Al_2	Aluminic

Mn_2	Manganic
Fe_2	Ferric
Cr_2	Chromic
Ni_2	Nickelic
Co_2	Cobaltic

820. Valence of Negative Radicals.
(ACIDULOUS RADICALS.)

Univalent.	*Forming.*
H	Hydrides
Cl	Chlorides
Br	Bromides
I	Iodides
F	Fluorides
Cy or (CN)	Cyanides
HO	Hydroxides (Hydrates)
ClO	Hypochlorites
CyO or (CNO)	Cyanates
HS	Hydrosulphides
CyS or (CNS)	Sulphocyanides
NO_2	Nitrites
NO_3	Nitrates
H_2PO_2	Hypophosphites
CHO_2	Formiates
$C_2H_3O_2$	Acetates
$C_5H_9O_2$	Valerates
$C_{16}H_{31}O_2$	Palmitates
$C_{18}H_{35}O_2$	Stearates
$C_{18}H_{33}O_2$	Oleates
$C_3H_5O_3$	Lactates
$C_6H_5SO_4$	Sulphocarbolates
$C_6H_2(NO_2)_3O$	Picrates
$C_7H_5O_3$	Salicylates
$C_7H_5O_2$	Benzoates
$C_9H_8O_2$	Cinnamates
$Mn\ O_4$	Permanganates

[ACIDULOUS-RADICALS.—*Continued.*]

Bivalent.

O	Oxides
S	Sulphides
SO_3	Sulphites
S_2O_3	Thiosulphates
SO_4	Sulphates
CO_3	Carbonates
C_2O_4	Oxalates
$HAsO_3$	Arsenites
$HSbO_3$	Antimonites
$C_4H_4O_4$	Succinates
$C_4H_4O_5$	Malates
$C_4H_4O_6$	Tartrates
CrO_4	Chromates
Cr_2O_7	Dichromates
B_4O_7	Pyroborates.

Trivalent.

PO_4	Phosphates
AsO_4	Arsenates
SbO_4	Antimonates
BO_3	Borates
$C_6H_5O_7$	Citrates
C_7HO_7	Meconates

Quadrivalent.

SiO_4	Silicates
P_2O_7	Pyrophosphates
As_2O_7	Pyroarsenates
Sb_2O_7	Pyroantimonates
$FeCy_6$	Ferrocyanides

Sexivalent.

Fe_2Cy_{12}	Ferricyanides.

CHAPTER XLII.

COMPOUND MOLECULES.

821. We have learnt that all molecules are made up of atoms; that elemental molecules are made up of atoms of but one kind; and the compound molecules are made up of two or more atoms of two or more different kinds.

822. Atomicity.—The number of atoms any molecule contains is expressed by the term *atomicity*.

A molecule consisting of but one atom is *monatomic*, a molecule containing two atoms (not *two kinds* of atoms, but two atoms, only, whether of the same kind or not) is *diatomic*, a molecule made up of three atoms is *triatomic*, one of four atoms is *tetratomic*, and one of five atoms is *pentatomic*, and a molecule containing six atoms is *hexatomic*.

Molecules containing more than two atoms are *polyatomic*.

823. The number of atoms which may unite to form one molecule is indefinite and subject to extreme differences.

Most of the elemental molecules are assumed to contain each two atoms. There are, however, elemental molecules supposed to contain one (mercury, zinc, cadmium and barium), three (oxygen as ozone), four (phosphorus and arsenic), and six (sulphur under certain conditions) atoms, respectively.

Of the compound molecules all binary compounds contain but two kinds of atoms, and many of them only one of each kind. Thus the chlorides, iodides and bromides of all univalent (612) metals, and the oxides and sulphides of the bivalent (612) metals, contain but two atoms in each molecule. But molecules composed of compound radicals may contain a large number of atoms.

A molecule of potassium iodide or calcium oxide contains two atoms; a molecule of water, three; ammonia, four; lead nitrate, five; copper sulphate, six; sodium sulphate, seven; phosphoric acid, eight; phenolphthalein, thirty-eight; olive oil (glyceryl oleate), one hundred and sixty-seven atoms, and the molecules of many organic compounds contain even a greater number of atoms.

Inorganic substances have, as a rule, a far more simple molecular structure than organic substances, if the present formulas of inorganic chemistry are the true ones.

824. Compound molecules are formed in various ways.

1. By direct union of the component elements, as:

$$X + Y = XY.$$
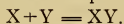
This reaction is, however, in most cases less simple than the equation indicates. It is really not a mere addition followed by chemical union, for the elemental molecules must first be decomposed into their constituent atoms, and in many cases the direct union of atoms depends upon a change of valence in the factors of the reaction under the influence of energetic chemical agents, as the elevation of bivalent C to quadrivalent C, or of Civ to Cvi, or of Niii to Nv, etc.

2. Chemical reactions may also consist of apparently simple subtraction:

$$YXZ - X = YZ + X.$$
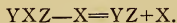
This is often the result of a reduction of valence of an element under the influence of high heat, as the reduction of Svi to Siv, or Nv to Niii. Examples of this splitting up of one molecule into several may be found in the products of the destructive distillation of organic substances. Heat has a tendency to lower the valence of elements.

But molecules may be divided by the influence of heat without any change in the valence of the atoms involved in the reaction, as when $CaCO_3$ is split up into CaO and CO_2, or when phosphate of sodium is converted into sodium pyrophosphate, by heat.

3. Molecules are formed by single selective affinity when *substitution* takes place, as when zinc is dissolved in hydrochloric acid—

$$Zn_2 + 4HCl = 2ZnCl_2 + 2H_2,$$
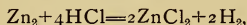
or when chlorine is introduced into the molecule of a hydrocarbon taking the place of its hydrogen, atom for atom.

4. Double decomposition is, however, the most frequently occurring form of chemical reactions; it is much more common than the three other kinds together. In double decomposition the products of the reaction generally have the same general structure as the factors, and there is simply a mutual interchange of radicals brought about by the chemical attraction working simultaneously in two directions but toward the same result.

825. All molecules, then, are composed of radicals, and all chemical reactions take place between radicals. When two different molecules are in contact with each other there may be a mutual interchange of radicals between them; or there may be a

transfer of a radical from one molecule to another; or new radi-
cals may be formed by the splitting up of existing compound
radicals; or by the removal of an atom or group of atoms; or by
the substitution of one atom or group of atoms for some other
atom or group of atoms; or additional radicals may be inserted
between those already contained in a molecule.

826. **Compound molecules** are formed in accordance with
the valences of the atoms or radicals of which they are consti-
tuted.

Equivalent (614) atoms or radicals unite directly in equal
numbers, or in the ratio of one to one.

Whenever any two atoms or radicals are united directly to
each other, each must present the same number of free bonds.
In other words, when two opposite radicals unite, there must be
an equal number of bonds on each side.

827. There can be no molecule with any free bond or bonds.
Every bond or valence unit presented by the atoms or radicals
present in the molecule is tied or saturated.

It follows from the preceding statement that the whole num-
ber of bonds in any molecule must be even. Again, if there are
any perissads in the molecule, their number must be even, as
otherwise the total number of bonds would not be even.

If there were an odd number of bonds or valence units, not
all could be paired and there would then of necessity be one or
more free bonds, which is impossible in a molecule.

828. Both simple and compound radicals may unite with
each other directly, or they may be joined together, like links,
in chains, or groups, or circles.

It is evident that two equivalent atoms can only form a pair, directly
united. But one dyad unites with two monads, two dyads with four monads,
or with one triad and one monad, or with one tetrad; three dyads with six
monads, or two triads, or with one monad, one dyad and one triad together;
etc. When more than two atoms or radicals are contained in one molecule
they can not all be directly united; but of three, four, or five radicals, one
may be in the center of the whole group directly united with each of the
others (713).

829. Direct union of atoms.—The simplest possible compound molecules are those formed by two equivalent atoms. Two monads, or two dyads, or two triads, or two tetrads mutually saturate each other. Thus:

H and Cl, both monads, form H—Cl, or HCl
K and I   "   .   "   "   K—l   or KI
Ag and Br,   "   "   "   Ag—Br, or AgBr
Ca and O,   "   dyads,   "   Ca=O, or CaO
Zn and S,   "   "   "   Zn=S, or ZnS.
B and N,   "   triads   "   B≡N, or BN.

830. But when the atoms or radicals are not equivalent the molecule is not so simple, for the number of free bonds on each side must then be the smallest common multiple of the numbers of their respective valence units.

Thus, if the valence of one radical is 1 and that of the other 3, it follows that each radical must present three bonds ; and if one has a valence of 2 and the other of 3, each radical must present 6 bonds, or such a number of atoms or groups as will have that total number of bonds.

Thus :

H^I	and	O^{II}	form	H_2O
H^I	"	S^{II}	"	S_2O
H^I	"	Cl^I	"	HCL
Cu^{II}	"	O^{II}	"	CuO
Cu_2^{II}	"	O^{II}	"	Cu_2O
Ca^{II}	"	Cl^I	"	$CaCl_2$
S^{IV}	"	O^{II}	"	SO_2
C^{IV}	"	O^{II}	"	CO_2
N^{III}	"	O^{II}	"	N_2O_3
As^{III}	"	O^{II}	"	As_2O_3
Al_2^{VI}	"	Cl^I	"	Al_2Cl_6
K^I	"	$(OH)^I$	"	KOH
$(BiO)^I$	"	$(OH)^I$	"	BiO.OH
Ba^{II}	"	$(OH)^I$	"	$Ba(OH)_2$
Fe^{II}	"	S^{II}	"	FeS
Hg_2^{II}	"	Cl^I	"	Hg_2Cl_2
Hg^{II}	"	Cl^I	"	$HgCl_2$
Sn^{IV}	"	Cl^I	"	$SnCl_4$
Fe_2^{VI}	"	$(FeCy_6)^{IV}$	"	$Fe_4(FeCy_6)_3$
Sb^V	"	S^{II}	"	Sb_2S_5
Pb^{II}	"	$(NO_3)^I$	"	$Pb(NO_3)_2$

Ca^{II}	and	$(OCl)^{I}$	form	$Ca(OCl)_2$
$(NH_4)^{I}$	"	$(SO_4)^{II}$	"	$(NH_4)_2SO_4$
Fe_2^{VI}	"	$(SO_4)^{II}$	"	$Fe_2(SO_4)_3$
Ca^{II}	"	$(CO_3)^{II}$	"	$CaCO_3$
K^{I}	"	$(C_6H_5O_7)^{III}$	"	$K_3C_6H_5O_7$

etc., etc., etc.

831. Chains.—Atoms and compound radicals with their so-called *bonds* may be likened to a number of boys with their hands. Any number of boys may form a chain by joining their hands together—one hand to the left, the other to the right. So can any number of atoms or compound radicals that have each two bonds, as:

$$—O—O—O—$$

There will still be one free bond at each end, just as the end boys in the chain would each have one hand free. But suppose you and I join hands, you taking my left hand in your right and my right hand in your left; both your hands and mine would be tied just as are the bonds of a calcium atom and an oxygen atom united into calcium oxide—

$$Ca=O.$$

But if one boy with two hands and two one-armed fellows form a chain, the boy with two hands will have to be in the middle and the others at the ends (we do not care much if one turns his back to us as would necessarily be the case if both boys had lost their left hands, or both the right hands), and there would be no chance of joining in with any more boys at either end, just as when two hydrogen atoms, each with but one bond, are united by an oxygen atom between them—

$$H—O—H.$$

A boy with three hands, if we could have one, would act like a nitrogen atom

$$\diagdown \underset{|}{N} \diagup$$

and could hold three other boys, one with each hand:

$$\overset{H}{\underset{}{\underset{|}{H—N—H}}}$$

or, instead of NH_3, we might have

$$\overset{H \quad H}{\underset{H}{\underset{|}{H—N—C—H}}}$$
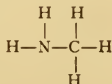
for carbon has four bonds.

You can see, then, that all monads which enter into any molecule must be at the ends or on the outside (the one-armed boys at the end of the line); that

dyads can form a long chain by extending their two bonds in opposite directions or they can form a ring; that triads can form the centers of triangles, and tetrads the centers of squares, as well as rings, etc.

832. Linkage.—In any molecule consisting of more than two atoms, then, one or more of these atoms, or any group of atoms through one of their number, must perform a linking function. In other words, the atoms in such molecules are not so combined that each and every atom is united directly to every other atom, but two univalent atoms may be linked together by a bivalent atom as in the water molecule, H—O—H, or in potassium hydrate, K—O—H; or, if the molecule consists of at least two monads and at least two dyads, a longer **chain** may be formed, as in Cl—O—O—O—H; or if tetrads perform the linking function there may be **branched chain,** as in

$$\begin{array}{ccccc} H & H & H & H & H \\ | & | & | & | & | \\ H-C-C-C-C-C-H; \\ | & | & | & | & | \\ H & H & H & H & H \end{array}$$
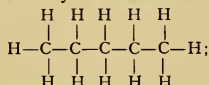
in which the hydrogen atoms are linked together by carbon; or we may have a triad linking together three monads, as in

$$\begin{array}{c} H \\ | \\ H-N-H; \end{array}$$

or a triad tying together one monad and one dyad, as in O=Bi—Cl; or a tetrad uniting two dyads as in O=C=O, or a tetrad uniting one monad and one triad as in K—C≡N, or three or four dyads joined together in a **closed chain** or **ring**, as in

$$\begin{array}{cc} S & S \\ \diagup\diagdown & \diagup\diagdown \\ O-O \ \text{and in} \ O \quad O; \\ & \diagdown\diagup \\ & O \end{array}$$
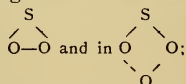
or such structures as indicated by the following examples may result:

$$\begin{array}{cc} \begin{array}{c} H \quad O \\ | \quad \| \\ H-C-C-O-H; \\ | \\ H \end{array} & \begin{array}{c} O-H \\ \diagup \\ O=P-O-H \\ \diagdown \\ O-H; \end{array} \end{array}$$

$$H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-Cl;$$

$$H-O-C-\underset{\underset{O}{\|}}{\overset{\overset{O}{\|}}{C}}-O-H;$$
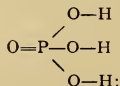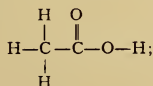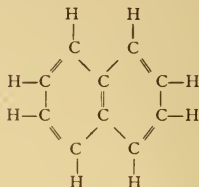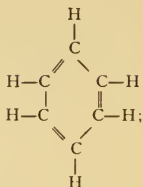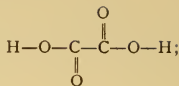
833. In all cases of indirect union or linkage, each linking atom must present the same total number of bonds as the several atoms linked together by it.

834. The formulas shown in paragraph 832 are presented only for the purpose of illustrating the manner in which the several atoms are held together in molecules, and how the valence units or bonds of the several atoms are all tied or satisfied, each bond from any one atom being united to one bond from some other atom, all the bonds being paired off in this manner.

But such formulas as these are not generally used because they are too unwieldly except for the purpose of portraying the internal structure of molecules

835. Molecular formulas are based upon the atomic theory (583), the theory of electro-chemical polarity (564), and the theory of valence (607); they may also be derived from or verified by the hypothesis of Avogadro (599), and the relation of specific heat to atomic and molecular weight (589).

A molecular formula of any compound stands for one molecule of the compound and for one molecular weight of it expressed in hydrogen units, just as any single symbol stands for one atom of the element it represents, and for the fixed relative weight of that atom as compared with that of hydrogen.

836. Empirical Formulas are molecular formulas reduced to the simplest form of expression showing the kinds of atoms

and the number of each. Thus the empirical formula for acetic acid is $C_2H_4O_2$. Such formulas are deduced from the percentage composition ascertained by ultimate quantitative analysis. An empirical formula is correct so far as it goes, but does not show the interior arrangement of the atoms or their relative positions, except in compounds of simple radicals.

837. The molecular formulas of inorganic compounds, as commonly written, are nearly always the empirical formulas, and they show the structure in many cases because the compounds of inorganic chemistry are very simple.

When more than three different kinds of atoms enter into a molecule, however, the commonly-used formulas seldom express the internal structure.

The almost universal practice is to write the molecular formulas of salts (892), as if they consisted of a metal as the positive radical and an acid-residue (814) as the negative radical, and this method has been found sufficient as well as convenient.

838. **Rational, Constitutional or Structural Formulas** are molecular formulas which express the relations existing between the several groups of atoms composing the molecule. The relations which exist between the several parts of any compound may be determined by its reactions or decompositions, its syntheses and the valences of the several elements of which it is composed.

Thus, the groups CH_3, CO and OH are assumed to exist in acetic acid, because these groups of atoms can be made to enter or leave the molecule unchanged.

As CO is a bivalent radical, and OH and CH_3 each univalent, the rational formula of acetic acid is written $CH_3.CO.OH$, and it is assumed to be composed of methyl (CH_3), carbonyl (CO) and hydroxyl (OH).

Rational, constitutional or structural formulas are valuable, because they explain the character and conduct of compounds, in addition to their atomic composition, indicating their origin or the substances from which they are derived and those into which they may be resolved.

839. **Type Theory.**—Some chemists have classified all chemical compounds into a few groups, each group being referred to some fundamental *type* (Dumas, Laurent and Gerhardt).

The proposed types are:

HCl	H_2O	H_3N	H_4C
Hydrogen Chloride	Water	Ammonia	Methane

It was assumed that all other compounds are derivatives of one or the other, or of more than one of these types, or that the molecular structure of any other compound conforms to the general plan of one or more of the four fundamental types.

As developed by Gerhardt the theory of types gradually led to serious difficulties, greater importance being attached to the new theory than to the atomtic weights. Out of it grew the modified or modern type theory of Kekulé, and the *graphic formulas* of Kekulé and Frankland.

The types and their derivatives are illustrated by the following table:

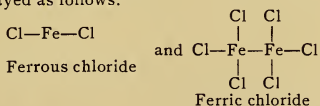|			
Hydrochloric acid	$\left.\begin{array}{l}\text{H}\\\text{Cl}\end{array}\right\}$	Ammonia	$\left.\begin{array}{l}\text{H}\\\text{H}\\\text{H}\end{array}\right\}\text{N}$
Ethyl chloride	$\left.\begin{array}{l}\text{C}_2\text{H}_5\\\text{Cl}\end{array}\right\}$	Methylamine	$\left.\begin{array}{l}\text{CH}_3\\\text{H}\\\text{H}\end{array}\right\}\text{N}$
Acetyl chloride	$\left.\begin{array}{l}\text{C}_2\text{H}_3\text{O}\\\text{Cl}\end{array}\right\}$	Dimethylamine	$\left.\begin{array}{l}\text{CH}_3\\\text{CH}_3\\\text{H}\end{array}\right\}\text{N}$
Cyanogen chloride	$\left.\begin{array}{l}\text{CN}\\\text{Cl}\end{array}\right\}$	Trimethylamine	$\left.\begin{array}{l}\text{CH}_3\\\text{CH}_3\\\text{CH}_3\end{array}\right\}\text{N}$
————		————	
Water	$\left.\begin{array}{l}\text{H}\\\text{H}\end{array}\right\}\text{O}$	Methane	$\left.\begin{array}{l}\text{H}\\\text{H}\\\text{H}\\\text{H}\end{array}\right\}\text{C}$
Ethyl alcohol	$\left.\begin{array}{l}\text{C}_2\text{H}_5\\\text{H}\end{array}\right\}\text{O}$	Chlormethane	$\left.\begin{array}{l}\text{H}\\\text{H}\\\text{H}\\\text{Cl}\end{array}\right\}\text{C}$
Ethyl ether	$\left.\begin{array}{l}\text{C}_2\text{H}_5\\\text{C}_0\text{H}_5\end{array}\right\}\text{O}$	Methyl alcohol	$\left.\begin{array}{l}\text{OH}\\\text{H}\\\text{H}\\\text{H}\end{array}\right\}\text{C}$
Acetic acid	$\left.\begin{array}{l}\text{C}_2\text{H}_3\text{O}\\\text{H}\end{array}\right\}\text{O}$	Isopropyl alcohol	$\left.\begin{array}{l}\text{CH}_3\\\text{CH}_3\\\text{OH}\\\text{H}\end{array}\right\}\text{C}$

840. The relationship of natural groups of elements is generally disclosed by the molecular formulas of their compounds, and the difference between radicals as to their valence may at the same time be illustrated by placing several groups of molecular formulas beside each other, thus—

ClH	OH_2	NH_3	CH_4
BrH	SH_2	PH_3	SiH_4
IH	SeH_2	AsH_3	$TiCl_4$
FH	TeH_2	SbH_3	$SnCl_4$
CyH	$MgCl_2$	$BiCl_3$	
KCl	$ZnCl_2$		

841. But the relative combining value of an element is not always evident from the molecular formulas of its compounds compared with other similar formulas.

In fact it is easy to be led into erroneous ideas in some cases by a superficial comparison of formulas.

For instance, the formulas Sb_2O_3, As_2O_3, N_2O_3, Bi_2O_3, Cl_2O_3, Fe_2O_3, Mn_2O_3, Cr_2O_3, Al_2O_3, Ni_2O_3 and Co_2O_3 might lead us to suppose that each of the several elements united to oxygen in these formulas must be trivalent, which is not the case. A thorough examination of all the known compounds has led to the adoption of some one ruling valence for each element, and the apparent inconsistencies can be explained more or less satisfactorily. If the formula for ferrous chloride is really $FeCl_2$ and not Fe_2Cl_4, we would naturally regard Fe as bivalent and not quadrivalent in that compound; but the Fe in Fe_2Cl_6 is not trivalent but quadrivalent. Graphically the two chlorides of iron may be portrayed as follows:

$$Cl—Fe—Cl$$

Ferrous chloride

$$\text{and} \quad \begin{array}{cc} Cl & Cl \\ | & | \\ Cl—Fe—Fe—Cl \\ | & | \\ Cl & Cl \end{array}$$

Ferric chloride

In mercurous and cuprous compounds the groups Hg_2 and Cu_2 are apparently bivalent; but in mercuric and cupric compounds the single atoms of Hg and Cu are also bivalent.

842. Substitution.—Certain atoms or radicals have the power to crowd out other atoms or radicals from molecules. Those of equal valence replace each other in equal numbers (614). But a bivalent radical may replace two monads, etc. The atom or radical thus displaced and replaced may be at the end of a chain, or in the middle of it or of a ring or closed chain, or in the center of a group, or it may be one of the atoms in a compound radical.

Chlorine can be introduced into the molecule CH_4, one or two or three or all of the atoms of H being *replaced* by Cl, producing CH_3Cl, CH_2Cl_2, $CHCl_3$ or CCl_4 as the case may be. Chlorine is then said to be substituted for the hydrogen.

In the same manner guncotton is derived from cotton by substitution, the group NO_2 replacing H.

843. **Derivatives** are compounds formed by substitution or replacement of one or more atoms or groups of atoms in a molecule, the general structure of which remains similar. The terms "derivative" and "substitution product" are synonymous.

Entire series of compounds, differing from each other by some fixed group of atoms or by a multiple of that group, are known. The marsh gas series of hydrocarbons beginning with CH_4 consists of many members, each differing from the next preceding member by CH_2. Such a series is called a *homologous series*. It can be assumed that these compounds are formed by substitution, one atom of H being replaced by one group of CH_3, by which CH_4 would give rise to C_2H_6, the latter to C_3H_8, etc.

CHAPTER XLIII.

CLASSES OF COMPOUNDS.

844. Compound molecules consist of two or more kinds of atoms. Those that contain but two kinds of atoms are called *binary compounds* those that are composed of three kinds of atoms are *ternary compounds;* if four kinds of atoms are united in one molecule the compound is called *quaternary*. But these distinctions are of little value as compared with a classification based upon the manner in which the atoms are united and the chemical behavior of the resulting compounds.

845. Chemical compounds are commonly classified into certain natural groups according to their general structure and chemical properties. The principal classes are as follows:

A. Inorganic Compounds.

1. Oxides.
2. Sulphides.
3. Haloids (Chlorides, Bromides, Iodides and Cyanides).
4. Bases.
5. Acids.
6. Salts.

B. Organic Compounus.

1. Hydrocarbons.
2. Organic Haloids.
3. Alcohols (and Mercaptans).
4. Aldehydes.
5. Ketones.
6. Acids.

7. Ethers or Oxides.
8. Ethereal Salts.
9. Carbohydrates.
10. Glucosides.
11. Akaloids.

CHAPTER XLIV.

OXIDES AND SULPHIDES.

846. Oxides. Whenever any radical unites with oxygen directly the resulting compound is called an *oxide*.

All elements except fluorine combine with oxygen, and there are accordingly a great number of oxides of both non-metallic and metallic elements. There are also oxides formed by compound radicals. Many of the elements form each more than one oxide (579), combining with oxygen in more than one proportion. *Higher oxides* contain a greater proportion of oxygen than the *lower oxides* of the same radicals.

847. Acid-forming oxides are those oxides which have the power to form acids with water. They are also called *anhydrides* of the acids.

Sulphuric oxide, or sulphuric anhydride, is the oxide SO_3, which, when added to water, forms, by chemical reaction, sulphuric acid, H_2SO_4.

Phosphoric anhydride, P_2O_5, forms phosphoric acid with water.

Nitrogen pentoxide, or nitric anhydride, with water, forms nitric acid.

The oxides of the non-metallic elements, especially their higher oxides, are acid formers or anhydrides.

Acid-forming oxides can unite directly with basic oxides (848) to form salts (892). Thus SO_3 with MgO will form $MgSO_4$.

848. Basic oxides are oxides which have the power to form basic hydrates (874) with water, or which combine with acids to form salts. The basic oxides or base-forming oxides, as a class, do not contain as much oxygen as the acid-forming oxides. Oxides of the metals are nearly always basic.

849. Indifferent or neutral oxides are those oxides which form neither acids nor bases.

N_2O, N_2O_2, N_2O_4, MnO_2, Mn_3O_4, PbO_2, etc., are examples.

850. All oxides may be said to be *insoluble* in water; they either react with water to form acids or bases; or, if not changed chemically by water, they are not dissolved

851. Preparation of Oxides.—The metallic oxides are produced by heating the hydrates or carbonates (919), or by oxidizing the metals (802), or by double decomposition between the metallic salts and the alkali hydrates (874).

852. Officinal Oxides.—Water, Chromic Anhydride (called "chromic acid"); Arsenous Anhydride (called "arsenous acid"); Calcium Oxide (called "lime"); Magnesium Oxide (called "magnesia"); Zinc Oxide, Mercuric Oxide (red and yellow), Silver Oxide and Antimonous Oxide.

853. *Table of Common Oxides, with their Molecular Formulas and Molecular Weights:*

Names	*Formulas*	*Molecular Weights.*
Hydrogen (water)	H_2O	18
Potassium	K_2O	94
Sodium	Na_2O	62
Lithium	Li_2O	30
Silver	Ag_2O	232
Mercurous	Hg_2O	416
Cuprous	Cu_2O	143
Nitrogen Monoxide	N_2O	44
Calcium	CaO	56
Barium	BaO	153
Strontium	SrO	103
Magnesium	MgO	40.3
Zinc	ZnO	81
Cadmium	CdO	128
Mercuric	HgO	216

Names.	Formulas	Molecular Weights.
Cupric	$Cu\,O$	79.2
Carbon	$C\,O$	28
Lead	$Pb\,O$	222.4
Manganous	$Mn\,O$	71
Ferrous	$Fe\,O$	72
Cobaltous	$Co\,O$	74.6
Nickelous	$Ni\,O$	74.6
Sulphur dioxide	$S\,O_2$	64
Carbon dioxide	$C\,O_2$	44
Tin dioxide	$Sn\,O_2$	151
Magnanese dioxiae	$Mn\,O_2$	87.
Nitrous Anhydride	$N_2\,O_3$	76.
Arsenous Anhydride	$As_2\,O_3$	198
Antimonous	$Sb_2\,O_3$	288
Bismuthous	$Bi_2\,O_3$	466
Boron	$B_2\,O_3$	70
Aluminum	$Al_2\,O_3$	102
Chromic	$Cr_2\,O_3$	152
Manganic	$Mn_2\,O_3$	158
Ferric	$Fe_2\,O_3$	160
Cobaltic	$Co_2\,O_3$	165.2
Nickelic	$Ni_2\,O_3$	165.2
Chromic Anhydrid	$Cr\,O_3$	100
Nitrogen	$N_2\,O_4$	92
Manganese	$Mn_3\,O_4$	229
Iron	$Fe_3\,O_4$	232
Lead	$Pb_3\,O_4$	683.
Nitrogen v	$N_2\,O_5$	108
Phosphorus	$P_2\,O_5$	142
Arsenic	$As_2\,O_5$	230
Antimonic	$Sb_2\,O_5$	320

854. Sulphides.—When any positive radical unites with sulphur the compound thus produced is a *sulphide*.

Analagous with the acid-forming and base-forming oxides are the acid-forming and base-forming sulphides, which have the power to unite with each other to form sulphur-salts.

The sulphides of hydrogen, carbon, arsenic, antimony, and the electro-positive radicals generally, are commonly occurring compounds.

855. The only *water-soluble sulphides* are those of hydrogen, the alkali metals, and the alkaline earth metals.

856. Preparation of Sulphides.—Sulphides are prepared in various ways.

Sulphur does not combine with hydrogen except when both are in the nascent state, and hence hydrogen sulphide can only be made by decomposing other sulphides with acids.

Carbon sulphide is produced by slowly heating carbon and sulphur together.

Metallic sulphides are made by strongly heating the metal (or its hydrate or carbonate) with sulphur, or by double decomposition between metallic salts and hydrogen sulphide or other water-soluble sulphides.

857. Official Sulphides.—Hydrogen Sulphide (used as a reagent only), Carbon Disulphide (called commonly "bisulphide of carbon"), impure Potassium Sulphide (called "sulphurated potassa," or "liver of sulphur") Sodium Sulphide, Ammonium Sulphide (as a reagent only), impure Calcium Sulphide (called "sulphurated lime"), Ferrous Sulphide (as a material for preparing hydrogen sulphide), Antimonous Sulphide (as crude "black sulphide of antimony"), purified black sulphide, and precipitated brownish orange-yellow sulphide (called "sulphurated antimony"), Antimonic Sulphide, and the very indefinite so-called Oxy-sulphuret of Antimony (also called "Kermes Mineral").

858. *Table of Common Sulphides with their Molecular Formulas and Molecular Weights.*

Names.	Formulas.	Molecular Weights.
Hydrogen	$H_2 S$	34
Potassium	$K_2 S$	110
Sodium	$Na_2 S$	78
Ammonium	$(NH_4)_2 S$	68
Silver	$Ag_2 S$	247.4
Mercurous	$Hg_2 S$	432
Cuprous	$Cu_2 S$	158.4
Calcium	$Ca S$	72
Strontium	$Sr S$	119.3
Barium	$Ba S$	169.
Zinc	$Zn S$	97.2
Cadmium	$Cd S$	144
Cobalt	$Co S$	91
Nickel	$Ni S$	90.7
Manganous	$Mn S$	87.
Ferrous	$Fe S$	88
Mercuric	$Hg S$	232
Cupric	$Cu S$	95.4
Plumbic	$Pb S$	238.9
Iron Bisulphide	$Fe S_2$	120
Arsenous	$As_2 S_3$	246
Antimonous	$Sb_2 S_3$	336
Bismuthous	$Bi_2 S_3$	513.8
Arsenic	$As_2 S_5$	310
Antimonic	$Sb_2 S_5$	400

CHAPTER XLV.

859. Haloids are the compounds formed by metals or positive compound radicals with any one of the halogens (696), which are fluorine, chlorine, bromine, iodine, cyanogen (and ferrocyanogen).

The haloids are also called "haloid salts," which is tautological.

Chlorides, bromides, iodides, and cyanides are the principal haloids. The haloids of hydrogen are the so-called hydrogen acids (888).

860. Chlorides are formed by direct union of positive radicals with chlorine.

Thus we have chlorides of hydrogen and of all the metals, and also of positive compound radicals, as of NH_4, NH_2Hg, CH_3, CH_2, CH, BiO, SbO, etc.

861. By *oxy-chloride* is meant a metallic chloride which is in some manner combined or associated with the oxide or hydrate of the same metal. Bismuthyl and antimonyl chlorides are both commonly called oxy-chlorides, because they contain oxygen; but they seem to be normal chlorides of compound radicals.

862. Chlorides are generally water-soluble; those of silver, lead, bismuthyl, antimonyl, and mercurous mercury are familiar exceptions.

863. Many of the chlorides are readily produced by saturating hydrochloric acid (hydrogen chloride), with the metals or their oxides, hydrates, or carbonates. Other chlorides are obtained by the action of free chlorine upon the proper radicals or their compounds, or by double decomposition between chlorides and other compounds.

Insoluble chlorides are, of course, prepared by precipitation (1022).

864. Officinal Chlorides.—Hydrochloric Acid, and the chlorides of Potassium, Sodium (common "salt") Lithium, Ammonium, Barium (as a reagent), Calcium, Zinc, Ferrous Iron, Ferric Iron (solid as well as in solution and in the tincture); Mercurous Mercury (the Mercurous Chloride is commonly called "calomel"); Mercuric Mercury (the Mercuric Chloride is com-

monly called "corrosive sublimate"); Mercur-Ammonium (the Mercur-Ammonium Chloride is commonly called "ammoniated mercury," and also "white precipitate"), and Gold (mixed with Sodium Chloride).

865. *Table of Common Chlorides with their Molecular Formulas and Molecular Weights:*

Names.	Formulas.	Molecular Weights.
Hydrogen (Hydrochloric Acid)	HCl	36.4
Potassium	KCl	74.6
Sodium	$NaCl$	58.5
Lithium	$LiCl$	42.5
Ammonium	NH_4Cl	53.5
Mercur-ammonium	NH_2HgCl	251.5
Silver	$AgCl$	143.4
Gold (Aurous)	$AuCl$	232.7
Antimonyl	$SbOCl$	171.4
Bismuthyl	$BiOCl$	258.9
Nitrosyl	$NOCl$	55.4
Mercurous	Hg_2Cl_2	470.9
Cuprous	Cu_2Cl_2	197.7
Calcium	$CaCl_2$	110.9
Strontium	$SrCl_2$	158.5
" with water	$SrCl_2.6H_2O$	266.6
Barium	$BaCl_2$	207.9
" with water	$BaCl_2.2H_2O$	243.9
Magnesium	$MgCl_2$	95.2
" with water	$MgCl_2.6H_2O$	203.3
Zinc	$ZnCl_2$	136.2
Cadmium	$CdCl_2$	182.9
" with water	$CdCl_2.2H_2O$	218.9
Mercuric	$HgCl_2$	270.9

Names.	Formulas.	Molecular Weights.
Cupric	$Cu\ Cl_2$	134.3
" with water	$Cu\ Cl_2 2H_2O$	152.3
Molybdous	$Mo\ Cl_2$	166.9
Platinous	$Pt\ Cl_2$	265.9
Stannous	$Sn\ Cl_2$	189.9
" with water	$Sn\ Cl_2 2H_2O$	207.9
Plumbic	$Pb\ Cl_2$	277.9
Chromous	$Cr\ Cl_2$	123
Manganous	$Mn\ Cl_2$	125.9
" with water	$Mn\ Cl_2 4H_2O$	198
Ferrous	$Fe\ Cl_2$	126.9
" with water	$Fe\ Cl_2 4H_2O$	198.9
Cobaltous	$Co\ Cl_2$	129.9
" with water	$Co\ Cl_2 6H_2O$	238
Nickelous	$Ni\ Cl_2$	129.6
" with water	$Ni\ Cl_2 6H_2O$	237.7
Nitrogen trichloride	$N\ Cl_3$	120.4
Phosphorus "	$P\ Cl_3$	137.4
Arsenic " (ous)	$As\ Cl_3$	181.3
Antimony " (ous)	$Sb\ Cl_3$	226.3
Bismuth " (ous)	$Bi\ Cl_3$	315.3
Gold (Auric)	$Au\ Cl_3$	303.6
Stannic	$Sn\ Cl_4$	260.8
Molybdic	$Mo\ Cl_4$	237.8
Platinic	$Pt\ Cl_4$	336.8
Uranous	$U\ Cl_4$	381.4
Phosphorus pentachloride	$P\ Cl_5$	209.3
Antimonic	$Sb\ Cl_5$	297.3
Tungstic chloride	$W\ Cl_6$	396.7
Manganic	$Mn_2\ Cl_6$	322.7

Names.	Formulas.	Molecular Weights.
Ferric	Fe_2Cl_6	324.7
" with water	$Fe_2Cl_6 \cdot 12H_2O$	540.9
Cobaltic	Co_2Cl_6	271.7
Chromic	Cr_2Cl_6	316.9
" with water	$Cr_2Cl_6 \cdot 12H_2O$	533
Aluminum	Al_2Cl_6	266.7
Cerium	Ce_2Cl_6	493

866. Bromides are the compounds of positive radicals with bromine.

Hydrobromic acid and the bromides of Potassium, Sodium, Lithium, Ammonium, Calcium, Magnesium, Zinc and Iron are used in medicine and pharmacy. All of these are *water-soluble.* They are *prepared* in various ways, as by saturating hydrobromic acid with oxides, hydrates, or carbonates; by the action of bromine upon a metal in the presence of water; by the chemical solution of bromine in the solution of potassium or sodium hydrate, and by double decomposition between bromides and other compounds.

867. *Table of Common Bromides with the Molecular Formulas and Molecular Weights.*

Names.	Formulas.	Molecular Weights.
Hydrogen (Hydrobromic Acid)	HBr	80.9
Potassium	KBr	119
Sodium	$NaBr$	103
Lithium	$LiBr$	87
Ammonium	NH_4Br	98
Silver	$AgBr$	187.9

Names.	Formulas.	Molecular Weights.
Calcium	Ca Br_2	199.9
Magnesium	Mg Br_2	184.2
Zinc	Zn Br_2	225.2
Ferrous	Fe Br_2	215.9
Ferric	$Fe_2 Br_6$	591.7

868.   Iodides are the compounds of positive radicals with iodine.

The iodides which are met with in pharmaceutical work are *water-soluble* with the exception of those of silver, mercury and lead; mercurous iodide is quite insoluble in water; mercuric iodide is nearly insoluble in cold water and sparingly soluble in boiling water; and lead iodide requires about 200 times its weight of boiling water to dissolve it.

869. *Preparation of Iodides.*—They are prepared from iodine, potassium iodide or iodide of iron.

Hydriodic acid is made by bringing hydrogen sulphide in contact with iodine in water, when the sulphur gives up its place to the iodine: $2I_2 + 2H_2S = 4HI + S_2$. Iodides of potassium and sodium may be obtained (together with some iodate) by dissolving iodine in solutions of the alkali hydrates, or by double decomposition from iron iodide. Iodides of sulphur, iron, zinc and mercurous mercury can be prepared by direct union of the elements.   Other methods of preparation of iodides depend upon double decomposition between some water-soluble iodide and some other compound, as when hydriodic acid is made from potassium iodide and tartaric acid:

$$KI + H_2C_4H_4O_6 = HI + KHC_4H_4O_6.$$

The insoluble iodides of silver, lead and mercuric mercury are made by precipitation (double decomposition), potassium iodide being one of the factors of the reaction.

The most common methods of making the iodides of potassium, sodium, ammonium and calcium depend upon double decomposition with iodide of iron.

870. **Officinal Iodides.**—Hydriodic Acid (in the form of Syrup) and the Iodides of Sulphur, Arsenic, Potassium, Sodium, Lithium, Ammonium, Calcium, Zinc, Ferrous Iron (in the form of the solid salt, saccharated iodide, syrup and glycerite), Lead, Mercurous Mercury (this iodide being commonly called "green iodide of mercury" or "protiodide of mercury") Mercuric Mercury (the mercuric iodide being commonly called "red iodide of mercury" or "bin-iodide of mercury") and Silver.

871. *Table of Common Iodides with their Molecular Formulas and Molecular Weights:*

Names.	Formulas.	Molecular Weights.
Hydrogen	$H\ I$	127.8
Potassium	$K\ I$	166
Sodium	$Na\ I$	149.9
Lithium	$L\ I$	133.9
Ammonium	$NH_4\ I$	144.9
Silver	$Ag\ I$	234.8
Bismuthyl	$BiO\ I$	351.8
Mercurous	$Hg_2\ I_2$	653.7
Calcium	$Ca\ I_2$	293.7
Barium	$Ba\ I_2$	390.7
Strontium	$Sr\ I_2$	341.3
Zinc	$Zn\ I_2$	319
Cadmium	$Cd\ I_2$	365.7
Mercuric	$Hg\ I_2$	453.7
Plumbic	$Pb\ I_2$	460.7
Manganous	$Mn\ I_2$	308.7

Names.	Formulas.	Molecular Weights.
Ferrous	Fe_2	309.7
Sulphur	S_2I_2	317.8
Arsenous	As_3	455.6
Ferric	Fe_2I_6	873 1

872. **Cyanides** are the compounds of positive radicals with the compound radical CN, called cyanogen; ferro-cyanides with the radical $FeCy_6$.

The only cyanides of pharmaceutical interest are hydrogen cyanide or Hydrocyanic Acid (also called "Prussic acid"), Potassium Cyanide, Silver Cyanide, Mercuric Cyanide, Ferro-cyanide of Potassium (called commonly "yellow prussiate of potash"), Ferricyanide of Potassium (as a reagent only), and Ferrocyanide of Iron (commonly called "Prussian blue").

The cyanides of hydrogen, potassium and mercury are water-soluble.

Hydrocyanic acid is prepared by the decomposition of ferro-cyanide of potassium with sulphuric acid, or by decomposing silver cyanide with hydrochloric acid. Other cyanides, and the ferrocyanides, are also made by double decomposition.

873. *Table of Common Cyanides, Ferrocyanides and Ferricyan-ides, with their Molecular Formulas and Molecular Weights:*

Names.	Formulas.	Molecular Weights.
Hydrogen (Hydrocyanic acid)	H_{CN}	27
Potassium	K_{CN}	65
Silver	Ag_{CN}	133.9
Zinc	$Zn_{(CN)_2}$	117.3

Names.	Formulas.	Molecular Weights.
Mercuric	$Hg(CN)_2$	252
Ferrocyanides.		
Potassium	$K_4Fe(CN)_6.3H_2O$	422.5
Iron	$Fe_4(FeCy_6)_3$	860
Ferricyanide.		
Potassium	$K_3Fe(CN)_6$	329

CHAPTER XLVI.

BASES.

874. Bases or Hydrates are the compounds formed by positive radicals with the compound radical HO or OH, called *hydroxyl*. Hydrates are also called *hydroxides*.

Bases are formed when basic oxides are brought in contact with water. Sometimes the metallic oxides react violently with water, as the oxides of the alkali metals, and in a less degree the oxides of the alkaline earth metals; other metallic oxides react with water but slowly; others, again, not at all.

Bases unite with acids to form salts.

The hydrates of potassium, sodium and ammonium are called *alkalies*, and these are extremely caustic, corrosive, or destructive to organic matter, so that they must be cautiously handled.

875. The freely *water-soluble* hydrates are the alkalies. Sparingly water-soluble are the hydrates of lithium, barium, strontium and calcium. The other metallic hydrates are *insoluble* in water.

The water-soluble bases turn certain red vegetable colors blue.

876. The hydrates of potassium and sodium are *prepared* from the carbonates by double decomposition with calcium hydrate. Ammonium hydrate is prepared by decomposition of ammonium chloride with calcium oxide. The alkali hydrates are largely employed in pharmaceutical chemistry as precipitants in making insoluble hydrates and oxides, etc.

The hydrates of calcium and barium are made by adding water to the oxides.

Insoluble metallic hydrates are made by precipitation (double decomposition).

877. Officinal hydrates.—Potassium Hydrate (commonly called " potassa " and " caustic potash "), Sodium Hydrate (commonly called " soda," or " caustic soda "), Ammonium Hydrate (in the form of solution called " ammonia water," or " caustic ammonia," or " spirit of hartshorn "), Barium Hydrate (used in volumetric analysis), Calcium Hydrate (in the form of solution commonly called "lime water"; in the solid state it is called, in common parlance, " slaked lime "), Aluminum Hydrate, and Ferric Hydrate (called " hydrated oxide of iron").

878. *Table of Common Hydrates with their Molecular Formulas and Molecular Weights.*

Names.	Formulas.	Molecular Weights.
Potassium	KOH	56
Sodium	$NaOH$	40
Lithium	$LiOH$	24
Ammonium	NH_4OH	35
Bismuthyl	$BiO.OH$	241.9
Calcium	$Ca(OH)_2$	74
Barium	$Ba(OH)_2$	171
" with water	$Ba(OH)_2.8H_2O$	315
Strontium	$Sr(OH)_2$	121.4
" with water	$Sr(OH)_2.8H_2O$	265.4
Magnesium	$Mg(OH)_2$	58.3

Names.	Formulas.	Molecular Weights.
Zinc	$Zn(OH)_2$	99.3
Cadmium	$Cd(OH)_2$	146
Cobaltous	$Co(OH)_2$	93
Nickelous	$Ni(OH)_2$	92.7
Manganous	$Mn(OH)_2$	89
Ferrous	$Fe(OH)_2$	90
Copper	$Cu(OH)_2$	96.4
Aluminic	$Al_2(OH)_6$	156
Chromic	$Cr_2(OH)_6$	206
Manganic	$Mn_2(OH)_6$	212
Ferric	$Fe_2(OH)_6$	214
Cobaltic	$Co_2(OH)_6$	228.4
Nickelic	$Ni_2(OH)_6$	219.4

879. **Basic Hydrates.**—By the term " basic hydrate," which is commonly used in works on chemistry and pharmacy, we mean a hydrate apparently combined in some way with the oxide of the same metal, as, for instance, the basic ferric hydrate which is represented as being $Fe_2O_3.Fe_2(OH)_6$.

880. **Base residues.**—When the replaceable hydrogen of a base—the hydrogen of its hydroxyl—is taken from its molecule, the remainder is called the residue of the base. Thus KO is the base residue of KOH.

881. The *saturating power* of a base—that is, its power to saturate acids—with reference to valence, is indicated by the number of hydroxyl groups contained in its molecule. As hydroxyl is a monad group, it follows that each such group is united to the positive element or radical by one bond, and that the base is capable of satisfying as many valence units of any acid radical as there are hydroxyl groups in the basic molecule.

The number of hydroxyl groups in any base is expressed by the term *acidity*. A base with one hydroxyl group is said to be *mon-acid* because it satisfies but one acid valence unit; a base

with two hydroxyl groups is *di-acid*, for it has the power of sat-
urating a molecule of an acid having a bivalent acid radical, or
of saturating two molecules of a mono-basic (885) acid; etc.

882. When a base is saturated by an acid, and a salt thus
formed, the hydroxyl of the base is replaced by an acid radical.
Thus KOH saturated by HNO_3 becomes KNO_3.

CHAPTER XLVII.

ACIDS.

883. Acids are the salts of hydrogen. They are of two
classes: 1, Hydroxyl Acids, and 2, Hydrogen Acids.

All the so-called *strong acids*, by which expression is meant
soluble acids exhibiting such chemical energy that they readily
react with metals or metallic oxides, have a sour or acid taste,
and turn blue litmus and certain other blue vegetable colors
red.

All acids combine with bases and metallic oxides forming
salts (992), water being simultaneously formed.

Several acids are so energetic as to attack and dissolve metals,
metallic oxides, hydrates and carbonates, and to decompose
sulphides, etc.

All acids contain positive hydrogen. This hydrogen can be
replaced by other positive radicals, as by metals and certain
compound radicals. In the acid the positive hydrogen is
united directly or indirectly to a negative radical, elemental or
compound.

Hydrogen is such a weak positive radical that it readily
yields its place to other positive radicals. Each acid contains
one or more atoms of hydrogen which can thus be replaced.

The *acid properties* of hydrogen salts, their energy in attack-

ing other substances, and their utility as materials for the production of various other compounds, depend upon the weak character of their positive radical—the hydrogen.

Any acid molecule may be split up into two parts—its *replaceable hydrogen* alone forms one part, and all of the remainder is called an *acid-residue*, or *acid-radical*.

Sulphuric acid, nitric acid, phosphoric acid, hydrochloric acid, hydrobromic acid, and oxalic acid, tartaric acid, citric acid, and acetic acid are among our most characteristic and pronounced acids, and the six first named are so extremely corrosive and destructive that they must be handled with great care.

884. **Hydroxyl acids.** A hydroxyl acid is a molecule consisting of *a negative radical united to hydroxyl*.

Hydroxyl acids are very numerous. As the hydrogen of the hydroxyl can be exchanged for other positive radicals, each hydroxyl group represents one valence unit of the residue (883). In other words, the number of hydroxyl groups in any acid determines its *basicity* (885).

Hydroxyl acids are also frequently called "true acids," or "oxy-acids," or "oxygen-acids," to distinguish them from hydrogen acids.

885. The *Basicity* of an acid is the valence of its residue or acid-radical. It is so called because it indicates the power of the acid to saturate bases by satisfying the valence units of the positive radical of the base.

Thus an acid having but one hydroxyl group in its molecule is *monobasic*, as it contains but one basic hydrogen atom; an acid containing two hydroxyl groups and, therefore, two basic hydrogen atoms, is a *bibasic* acid; an acid with three hydroxyl groups, or having a trivalent acid-radical, is *tribasic;* and an acid having four hydroxyl groups is *tetrabasic*, because its radical is capable of saturating four basic valence units, or has four replaceable positive or basic hydrogen atoms.

886. The most common hydroxyl acids are the following: (See also 809.)

Name.	*Formula.*	*Number of hydroxyl groups or replaceable hydrogen atoms*	*Basicity.*
Hypochlorous Acid	H ClO	1	Monobasic
Chloric Acid	H ClO$_3$	1	"
Iodic Acid	H IO$_3$	1	"
Nitrous Acid	H NO$_2$	1	"
Nitric Acid	H NO$_3$	1	"
Hypophosphorous Acid	H H$_2$PO$_2$	1	"
Metaphosphoric Acid	H PO$_3$	1	"
Acetic Acid	H C$_2$H$_3$O$_2$	1	"
Valeric Acid	H C$_5$H$_9$O$_2$	1	"
Lactic Acid	H C$_3$H$_5$O$_3$	1	"
Oleic Acid	H C$_{18}$H$_{33}$O$_2$	1	"
Phenyl-Sulphonic Acid	H C$_6$H$_5$SO	1	"
Salicylic Acid	H C$_7$H$_5$O$_3$	1	"
Benzoic Acid	H C$_7$H$_5$O$_2$	1	"
Sulphurous Acid	H$_2$ SO$_3$	2	Bibasic.
Sulphuric Acid	H$_2$ SO$_4$	2	"
Thiosulphuric Acid	H$_2$ S$_2$O$_3$	2	"
Phosphorous Acid	H$_2$ HPO$_3$	2	"
Arsenous Acid	H$_2$ HAsO$_3$	2	"
Antimonous Acid	H$_2$ HSbO$_3$	2	"
Carbonic Acid	H$_2$ CO$_3$	2	"
Oxalic Acid	H$_2$ C$_2$O$_4$	2	"
Silicic Acid	H$_2$ SiO$_3$	2	"
Stannic Acid	H$_2$ SnO$_3$	2	"
Pyroboric Acid	H$_2$ B$_4$O$_7$	2	"
Tartaric Acid	H$_2$ C$_4$H$_4$O$_6$	2	"
Succinic Acid	H$_2$ C$_4$H$_4$O$_4$	2	"
(Ortho-) Phosphoric Acid	H$_3$ PO$_4$	3	Tribasic.
(Ortho-) Arsenic Acid	H$_3$ AsO$_4$	3	"
Boric Acid	H$_3$ BO$_3$	3	"
Citric Acid	H$_3$ C$_6$H$_5$O$_7$	3	"
Malic Acid	H$_3$ C$_4$H$_3$O$_5$	3	"
Pyrophosphoric Acid	H$_4$ P$_2$O$_7$	4	Tetrabasic
Pyroarsenic Acid	H$_4$ As$_2$O$_7$	4	"

887. Reactions of Bases and Acids with each other.—We have seen that bases and acids are both hydroxyl compounds. It has also been stated that acids and bases react upon each other, forming salts, and at the same time water. It may be added that we can look at this double decomposition in several different ways: while it is commonly said that the basic hydrogen of the acid molecule is replaced by the positive radical of the base, we could with equal propriety say that the negative hydrogen of the base is replaced by the *acid-forming radical* of the acid, or that the hydroxyl of the base is replaced by the *acid-residue* or *acid radical*, or that the hydroxyl of the acid is replaced by the base residue. Thus—

$KOH + HNO_3 = KNO_3 + H_2O$ may be explained in either of the four different ways, for we can say that the HNO_3 has exchanged its H for K; or that the H of the KOH has been exchanged for the NO_2, which together with HO forms the HNO_3; or that the OH of the base has been replaced by NO_3; or that the hydroxyl group of the acid has been exchanged for KO.

It may also be said that when a base and a hydroxyl acid neutralize each other, the positive radical of the base unites with the negative acid radical, while the hydroxyl of the base unites with the positive hydrogen of the acid to form water.

888. Hydrogen Acids are the compounds of positive hydrogen with the halogens. They are also called *hydracids*. The hydrogen is replaceable by other positive radicals, resulting in the formation of *haloids* (859).

The hydrogen acids are all *monobasic*, because they all contain but one hydrogen atom. They are as follows:

Names.	*Formulas.*
Hydrofluoric Acid	H F
Hydrochloric Acid	H Cl
Hydrobromic Acid	H Br
Hydriodic Acid	H I
Hydrocyanic Acid	H CN

889. When a hydrogen acid and a base neutralize each other, the hydrogen of the acid unites with the hydroxyl of the base, while the halogen of the acid unites with the positive element or group of the base:

$$KOH+HCl=KCl+H_2O.$$
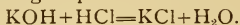
890. The action of acids on metals.—*Hydrochloric acid* dissolves zinc, aluminum, iron, nickel and tin; but does not attack lead, copper, mercury, silver, arsenic, antimony and bismuth.

When a metal is dissolved in hydrochloric acid, the hydrogen of the acid is always liberated, while the metal is turned into a chloride.

Sulphuric acid, diluted, attacks and dissolves zinc, iron and nickel, forming sulphates; dilute sulphuric acid does not attack aluminum, lead, copper, mercury, silver, arsenic, antimony and bismuth. The hydrogen of the acid is liberated, being displaced by the metal.

Concentrated sulphuric acid attacks copper, and, if hot, it also attacks mercury, silver and bismuth. In these cases a portion of the acid is decomposed into hydroxyl and SO_2, and another portion into hydrogen and SO_4; the SO_2 passes off as a gas, the hydroxyl forms water with the hydrogen, and the metal forms sulphate with the SO_4, so that the products of the reaction are three.

Nitric acid, when cold and dilute, dissolves zinc and iron with the formation of nitrates of the metals together with ammonium nitrate, the latter salt resulting from the decomposition of a portion of the acid by the nascent hydrogen replaced by the metal. Strong nitric acid does not attack iron.
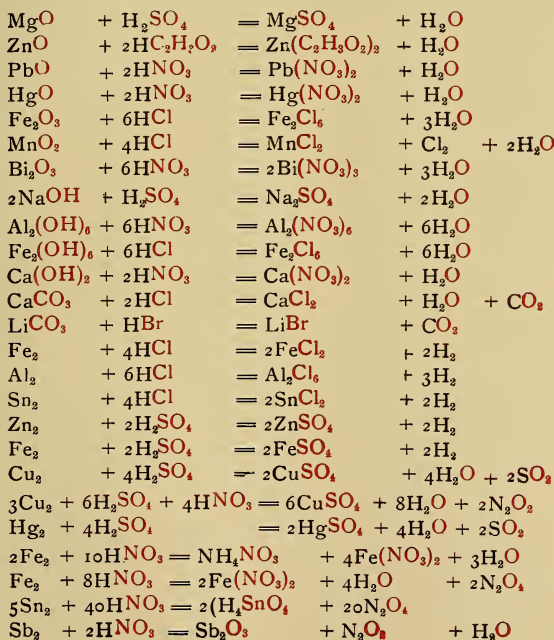
When warm dilute nitric acid attacks zinc, iron, nickel, lead, copper, mercury, silver, arsenic and bismuth, the acid radical itself is decomposed, either N_2O_2 or N_2O_4 being formed, and red fumes given off.

Strong nitric acid acting upon tin forms insoluble metastannic acid; antimony is oxidized by strong nitric acid to insoluble antimonous oxide.

Gold and Platinum are not attacked by any acid, but are dissolved by *aqua regia*. Aluminum is attacked by hydrochloric acid; silver by nitric acid.

The following equations represent the reactions which take place between acids and metals as described:

891. Strong acids dissolve metallic oxides, hydrates and carbonates in all cases where the new salt thus formed is water soluble. Thus we have:—

$$MgO \quad + H_2SO_4 \quad = MgSO_4 \quad + H_2O$$
$$ZnO \quad + 2HC_2H_2O_2 = Zn(C_2H_3O_2)_2 + H_2O$$
$$PbO \quad + 2HNO_3 \quad = Pb(NO_3)_2 \quad + H_2O$$
$$HgO \quad + 2HNO_3 \quad = Hg(NO_3)_2 \quad + H_2O$$
$$Fe_2O_3 \quad + 6HCl \quad = Fe_2Cl_6 \quad + 3H_2O$$
$$MnO_2 \quad + 4HCl \quad = MnCl_2 \quad + Cl_2 \quad + 2H_2O$$
$$Bi_2O_3 \quad + 6HNO_3 \quad = 2Bi(NO_3)_3 \quad + 3H_2O$$
$$2NaOH \quad + H_2SO_4 \quad = Na_2SO_4 \quad + 2H_2O$$
$$Al_2(OH)_6 + 6HNO_3 \quad = Al_2(NO_3)_6 \quad + 6H_2O$$
$$Fe_2(OH)_6 + 6HCl \quad = Fe_2Cl_6 \quad + 6H_2O$$
$$Ca(OH)_2 + 2HNO_3 \quad = Ca(NO_3)_2 \quad + H_2O$$
$$CaCO_3 \quad + 2HCl \quad = CaCl_2 \quad + H_2O \quad + CO_2$$
$$LiCO_3 \quad + HBr \quad = LiBr \quad + CO_2$$
$$Fe_2 \quad + 4HCl \quad = 2FeCl_2 \quad + 2H_2$$
$$Al_2 \quad + 6HCl \quad = Al_2Cl_6 \quad + 3H_2$$
$$Sn_2 \quad + 4HCl \quad = 2SnCl_2 \quad + 2H_2$$
$$Zn_2 \quad + 2H_2SO_4 \quad = 2ZnSO_4 \quad + 2H_2$$
$$Fe_2 \quad + 2H_2SO_4 \quad = 2FeSO_4 \quad + 2H_2$$
$$Cu_2 \quad + 4H_2SO_4 \quad = 2CuSO_4 \quad + 4H_2O + 2SO_2$$
$$3Cu_2 + 6H_2SO_4 + 4HNO_3 = 6CuSO_4 + 8H_2O + 2N_2O_2$$
$$Hg_2 \quad + 4H_2SO_4 \quad\quad = 2HgSO_4 + 4H_2O + 2SO_2$$
$$2Fe_2 + 10HNO_3 = NH_4NO_3 \quad + 4Fe(NO_3)_2 + 3H_2O$$
$$Fe_2 \quad + 8HNO_3 \quad = 2Fe(NO_3)_3 \quad + 4H_2O \quad + 2N_2O_4$$
$$5Sn_2 + 40HNO_3 = 2(H_4SnO_4 \quad + 20N_2O_4$$
$$Sb_2 \quad + 2HNO_3 = Sb_2O_3 \quad + N_2O_2 \quad + H_2O$$

CHAPTER XLVIII.

SALTS.

892. Salts are neutral compounds consisting of a metal or other positive radical united to an acid radical or to a halogen. They are produced by the action of acids upon metals, oxides, hydrates and carbonates, and sometimes by other means. Insoluble salts are generally produced by double decomposition of soluble salts.

Salts may be regarded as formed by replacing the basic hydrogen of an acid by some other positive radical; or by replacing the hydroxyl of an acid by a base-residue; or by replacing the oxygen of a basic oxide (848) by an acid radical (815).

The reactions presented in the two preceding paragraphs illustrate the formation of salts by the action of acids upon metals, oxides, hydrates and carbonates.

893. Salt radicals.—Salts may be regarded as consisting of two opposite kinds of radicals—*positive salt radicals*, which are either metals or other salt-forming positive radicals such as the compound radicals NH_4, CH_3, C_2H_5, C_6H_{11}, BiO, SbO, etc. (810 and 811); and *negative salt radicals*, which are the acid radicals (or acid residues) and the halogens.

894. Normal Salts (sometimes called *neutral salts*) are salts in which the acid radical is wholly saturated by any positive salt radical or radicals other than hydrogen. It is formed when all of the basic (or replaceable) hydrogen of an acid is replaced by one or more metals, or by any other positive salt radical. A normal salt results when an acid is saturated or neutralized by a base, or by a basic oxide. Thus, a normal salt does not contain any hydrogen that can be replaced by a metal or other positive radical. Each acid can form but one normal salt with each base.

895. Acid Salts are salts containing replaceable basic hydrogen, or salts in which the valence units of the acid radical are only partly neutralized by a salt radical, the remaining
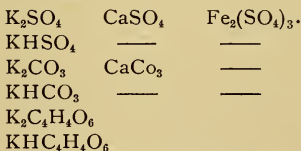
valence unit or units being united to hydrogen. They are formed when an acid containing more than one atom of replaceable hydrogen (more than one hydroxyl group) retains one or more of these hydrogen atoms, the other basic hydrogen atom or atoms being replaced by one or more salt radicals.

896. Thus monobasic acids (885) can not have any acid salts, but bibasic acids can each have one normal and one acid salt, and tribasic acids can have one normal and two different acid salts, with each monacid base.
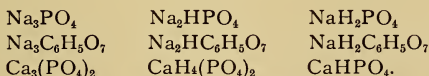
897. As nitric acid and hydrochloric acid are both monobasic (885), they have no acid salts, and their normal salts have formulas like the following :

$$KNO_3 \quad Pb(NO_3)_2 \quad Bi(NO_3)_3$$
$$KCl \quad PbCl_2 \quad BiCl_3$$
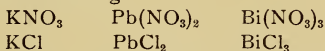
Sulphuric acid, carbonic acid and tartaric acid are bibasic, and they can, therefore, have each one normal and one acid salt with each monacid base :

$$K_2SO_4 \quad CaSO_4 \quad Fe_2(SO_4)_3.$$
$$KHSO_4 \quad \text{———} \quad \text{———}$$
$$K_2CO_3 \quad CaCo_3 \quad \text{———}$$
$$KHCO_3 \quad \text{———} \quad \text{———}$$
$$K_2C_4H_4O_6$$
$$KHC_4H_4O_6$$

Phosphoric acid and citric acid are tribasic, and we, therefore, have :

$$Na_3PO_4 \quad Na_2HPO_4 \quad NaH_2PO_4$$
$$Na_3C_6H_5O_7 \quad Na_2HC_6H_5O_7 \quad NaH_2C_6H_5O_7$$
$$Ca_3(PO_4)_2 \quad CaH_4(PO_4)_2 \quad CaHPO_4.$$

898. **Basic Salts.**—There are some compounds which seem to consist of a normal metallic salt combined with the hydrate or oxide of the same metal. These are called *basic salts*. Thus we have basic acetate of copper (verdigris), basic acetates of lead (of which the compound contained in solution of sub-acetate of lead is an example), basic acetate of iron, basic sulphates of iron (in Monsel's solution) and of mercury (yellow sulphate of mercury or turpeth

mineral), basic nitrates of mercury and basic carbonates of magnesium, zinc and lead. The molecular formulas given for some of these *basic salts* are as follows:

Magnesium Carbonate $= (MgCO_3)_4.Mg(OH)_2.5H_2O.$
Zinc Carbonate $= (ZnCO_3)_2. 3Zn(OH)_2.$
Lead Carbonate $= (PbCO_3)_2. Pb(OH)_2.$
Ferric Subsulphate $= Fe_4O(SO_4)_5.$
Basic Mercuric Sulphate $= (HgO)_3HgSO_4.$
Basic Lead Acetate $= Pb(C_2H_3O_2)_2. Pb(OH)_2.$
Basic Cupric Acetate $= Cu_2O(C_2H_3O_2)_2.$

899. Double Salts.—Salts containing two different positive salt radicals united to one negative salt radical (893) are called *double salts*.

If a bibasic acid exchanges one of its basic hydrogen atoms for one metal and the other hydrogen atom for another metal, the result is a double salt. Thus, sulphuric acid, H_2SO_4, may form $KNaSO_4$; tartaric acid, $H_2C_4H_4O_6$, forms $KNaC_4H_4O_6$, and $KSbOC_4H_4O_6$; and the alums are also double salts:

$Al_2K_2(SO_4)_4,$
$Al_2(NH_4)_2(SO_4)_4,$ and
$Fe_2(NH_4)_2(SO_4)_4.$
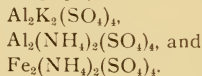
The scale salts of iron called citrate of iron and ammonium, citrate of iron and quinine, tartrate of iron and ammonium, tartrate of iron and potassium, phosphate of iron and pyro-phosphate of iron (both combined with sodium citrate), are not true double salts.

900. Oxy salts are the salts produced by hydroxyl acids or their acid radicals. Haloids are also commonly referred to as "salts" (859), although the definition just given, which is now generally accepted by many chemists, excludes them. In this book the definition of salts (892) includes the haloids, and the term will be used as applicable to both oxy-salts and haloids. Nevertheless we have placed the several groups of haloids by themselves by way of emphasizing the difference between haloids and oxy-salts.

The principal groups of oxy-salts of inorganic chemistry are the nitrates, chlorates, hypochlorites, sulphates, sulphites, phos-

phates, hypophosphites, carbonates and silicates.   But there are
also very important groups of salts formed by the organic acids
with inorganic bases; these groups are: Acetates, valerates,
lactates, oleates, oxalates, tartrates, citrates, phenyl-sulphonates,
salicylates and benzoates.

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CHAPTER XLIX.

NITRATES, CHLORATES, ETC.

901. **Nitrates** are the salts formed by nitric acid, or the
salts containing the characteristic group NO_3.   This acid-radical
(NO_3) is a monad.

The *nitrates of mercury and bismuth* are split up by water into
insoluble basic salts and acid; they can, therefore, not be dis-
solved in water alone, but are soluble in water containing a large
amount of nitric acid.   *All other nitrates are water-soluble.*

The metallic nitrates may be prepared by saturating nitric
acid with the metals, or their oxides, hydrates, or carbonates, or
by double decomposition if the bye-product (1026) be insoluble.
Even the nitrates of mercury and bismuth are prepared by dis-
solving these metals in nitric acid, but an excess of nitric acid
must then be used to retain the nitrates in solution.

902. The nitric radical (NO_3) is an unstable group, easily
giving up a portion of its oxygen. The decomposition of the
nitrate radical takes place both in nitric acid and in other
nitrates whenever a radical having a strong affinity for oxygen
is brought in contact with them. Nitric acid and sometimes
other nitrates are, therefore, used as *oxidizing agents* (1006). The
decomposition referred to is generally rapid and accompanied
by the evolution of a colorless gas, N_2O_2, which, however,
immediately changes in the air to N_2O_4, which is red. *Red fumes*
accordingly make their appearance on dissolving metals in

nitric acid. The application of heat hastens the decomposition of the nitric acid or the nitrate, and therefore, also the simultaneous oxidation (667) of the radical, which, by its affinity for oxygen, helps to cause the reaction. That radical is frequently the hydrogen of the nitric acid itself, as in—

$$3Cu_2 + 16HNO_3 = 6Cu(NO_3)_2 + 2N_2O_2 + 8H_2O.$$
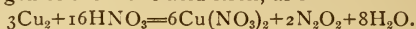
The oxygen removed from the nitrate radical is utilized directly or indirectly to change certain *–ous compounds* to *–ic compounds* (989 to 991).

903. The *officinal nitrates* are those of hydrogen (called nitric acid), potassium (called "nitre" or "saltpetre"), sodium (called "Chile-saltpetre") ammonium, silver (called "lunar caustic" when fused and molded into sticks), bismuthyl (called "subnitrate of bismuth"), barium (used as a reagent), mercuric mercury (contained in the "solution of nitrate of mercury"), lead, and ferric iron (in the "solution of nitrate of iron").

904. The following table contains the—

Common Nitrates, with their Molecular Formulas and Molecular Weights.

Names.	Formulas.	Molecular Weights.
Hydrogen (nitric acid)	HNO_3	63
Potassium	KNO_3	101
Sodium	$NaNO_3$	85
Ammonium	NH_4NO_3	80
Silver	$AgNO_3$	169.7
Bismuthyl	$BiONO_3 . H_2O$	305
Mercurous	$Hg_2(NO_3)_2$	524
" with water	$Hg_2(NO_3)_2 . 2H_2O$	550
Calcium	$Ca(NO_3)_2$	164
" with water	$Ca(NO_3)_2 . 4H_2O$	236

Names.	Formulas.	Molecular Weights.
Barium	$Ba(NO_3)_2$	261
Strontium	$Sr(NO_3)_2$	211.3
Magnesium	$Mg(NO_3)_2$	148.3
" with water	$Mg(NO_3)_2.6H_2O$	256.3
Zinc	$Zn(NO_3)_2$	189
Mercuric	$Hg(NO_3)_2$	324
Cupric	$Cu(NO_3)_2$	187.2
" with water	$Cu(NO_3)_2.3H_2O$	241.2
Lead	$Pb(NO_3)_2$	330.4
Manganous	$Mn(NO_3)_2$	179
" with water	$Mn(NO_3)_2.6H_2O$	287
Ferrous	$Fe(NO_3)_2$	180
Cobaltous	$Co(NO_3)_2$	183
" with water	$Co(NO_3)_2.6H_2O$	291
Nickelous	$Ni(NO_3)_2$	182.6
" with water	$Ni(NO_3)_2.6H_2O$	290.6
Bismuthous	$Bi(NO_3)_3.5H_2O$	485
Cerium	$Ce_2(NO_3)_6$	652
Aluminum	$Al_2(NO_3)_6$	426
" with water	$Al_2(NO_3)_6.18H_2O$	750
Ferric	$Fe_2(NO_3)_6$	484
Cobaltic	$Co_2(NO_3)_6$	490

905. **Chlorates** are the salts containing the radical ClO_3. The chlorates of potassium and sodium are officinal. These salts are unstable, exploding violently by percussion or by trituration with sulphur, tannin, sugar, etc.

Potassium chlorate is soluble in about 16 times its weight of water at common room temperatures, and sodium chlorate in about its own weight. They may be prepared by passing

chlorine into solutions of the hydrates, by which hypochlorites
are first formed and these afterwards decomposed by heat—
$6KOH + 3Cl_2 = 3KClO + 3KCl + 3H_2O$; and then $3KClO = KClO_3 + 2KCl$.

Instead of the alkali hydrate a mixture of calcium hydrate
with the chloride of the alkali metal is now generally employed.

The formulas and molecular weights are—

Potassium Chlorate = $K ClO_3$ = 122.4
Sodium Chlorate   = $Na ClO_3$ = 106.4

906. Hypochlorites contain ClO. They are unstable,
yielding chlorine upon the addition of acids, or even without
that addition. The "chlorinated lime," commonly called
"chloride of lime" and "bleaching powder," depends upon its
hypochlorite of calcium for its effects, and "Labarraque's Solu-
tion" ("solution of chlorinated soda") and *Eau de Jarelle* (con-
taining potassium hypochlorite) are similar. They are used as
disinfectants and for bleaching cotton and linen.

Potassium Hypochlorite = $K ClO$ = 90.4
Sodium   "   = $Na ClO$ = 74.4
Calcium   "   = $Ca ClO$ = 142.8

CHAPTER L.

SULPHATES AND SULPHITES.

907. Sulphates.—The sulphate radical is SO_4 and it is a
dyad. Sulphuric acid is, therefore, a bibasic acid. Sulphuric
acid decomposes the salts of other acids, as a rule, and may be
considered as the "strongest" of all the acids. The great energy
with which sulphuric acid attacks other substances, or its
extremely destructive effects, may be regarded as the resultant

of the chemical union of so powerful a negative radical as SO_4 to so weak a positive radical as hydrogen, and the ever present strong tendency of the acid radical to exchange the hydrogen for a more strongly positive element or group. Thus sulphuric acid may be considered an unstable compound, while the sulphates of the strongest electro-positive radicals are among the most stable of all compounds.

908. *Solubility.*—The sulphates of lead, barium and strontium are insoluble in water. Calcium sulphate is very sparingly water-soluble. Sulphate of mercury is decomposed by water. The other officinal metallic sulphates are water-soluble.

909. *Preparation.*—The soluble metallic sulphates, and also mercury sulphate, are made by the action of sulphuric acid upon the metals or their oxides, hydrates, carbonates, or chlorides, and the alkali sulphates are often obtained as by-products in the preparation of other salts. The insoluble sulphates are obtained by double decomposition as precipitates.

910. The officinal sulphates are many, and are included in the following

Table of Common Sulphates with their molecular formulas and molecular weights:

Names.	Formulas.	Molecular Weights.
Hydrogen (sulphuric acid)	H_2SO_4	98
Potassium, normal	K_2SO_4	174
Potassium, acid	$KHSO_4$	136
Sodium, normal	Na_2SO_4	142
Sodium, normal, cryst.	$Na_2SO_4.10H_2O$	322
Sodium, acid	$NaHSO_4$	120
Ammonium	$(NH_4)_2SO_4$	132
Calcium	$CaSO_4$	136
" with water	$CaSO_4.2H_2O$	172
Barium	$BaSO_4$	233
Strontium	$SrSO_4$	183.3
Magnesium, anhydrous	$MgSO_4$	120.3

Names.	Formulas.	Molecular Weights.
Magnesium, dried	$MgSO_4, 2H_2O$	156.3
" cryst. .	$MgSO_4, 7H_2O$	246.3
Zinc	$ZnSO_4$	161
" cryst.	$ZnSO_4, 7H_2O$	287
Ferrous, anhydrous	$FeSO_4$	152
" dried	$FeSO_4, H_2O$	170
" cryst.	$FeSO_4, 7H_2O$	278
Manganous	$MnSO_4$	151
" cryst.	$MnSO_4, 7H_2O$	223
Cupric	$CuSO_4$	159.2
" cryst.	$CuSO_4, 5H_2O$	249.2
Mercuric	$HgSO_4$	296
Aluminum	$Al_2(SO_4)_3$	342
" with water	$Al_2(SO_4)_3, 18H_2O$	666
Potassa alum	$K_2Al_2(SO_4)_4, 24H_2O$	948
Dried alum	$K_2Al_2(SO_4)_4$	516
Ammonia alum	$(NH_4)_2Al_2(SO_4)_4, 24H_2O$	906
Ammonio-ferric alum	$(NH_4)_2Fe_2(SO_4)_4, 24H_2O$	964
Ferric Sulphate	$Fe_2(SO_4)_3$	400
Ferric sulphate, basic	$Fe_4O(SO_4)_3$	730
Mercuric, basic	$(HgO)_2, HgSO_4$	728

911.   Thiosulphates.—The only thiosulphate of interest to pharmacists is the so-called "hyposulphite of sodium," which has the formula $Na_2S_2O_3, 5H_2O$ and the molecular weight 248.

912.   Sulphites are characterized by containing the radical SO_3, which is bivalent.   Sulphites are *reducing agents*, being converted into sulphates by taking up more oxygen.   They are not freely soluble in water, and are generally prepared by the action of SO_2 upon hydrates, or carbonates.   The solution obtained by passing the gas SO_2 into water is properly regarded as containing sulphurous acid, and is so named in the Pharmacopœia.

913. *The common sulphites with their molecular formulas and weights are:*

Names.	Formulas.	Molecular Weights.
Hydrogen (sulphurous acid)	H_2SO_3	82
Potassium	$K_2SO_3 \cdot 2H_2O$	194.2
Sodium	$Na_2SO_3 \cdot 7H_2O$	252
Calcium	$CaSO_3 \cdot 2H_2O$	156
Magnesium	$MgSO_3 \cdot 6H^2O$	212.3

CHAPTER LI.

PHOSPHATES, ETC.

914. Phosphates (ortho-phosphates).—The acid radical which forms the ortho-phosphates is the group PO_4, which acts as a triad, so that ortho-phosphoric acid is tribasic. The phosphates are very stable compounds, for the phosphate radical is a powerful negative radical.

The phosphates of potassium, sodium and ammonium are *water-soluble;* all other phosphates are *insoluble* in water. Ferric phosphate is soluble in solutions of citrates of potassium, sodium or ammonium, and the "phosphate of iron" of the Pharmacopœia is a compound consisting of the water-soluble scaled residue obtained from a solution of ferric phosphate in solution of sodium citrate.

The soluble phosphates may be produced by the action of phosphoric acid upon hydrates or carbonates, but all phosphates

are generally *prepared* by double decomposition. Phosphates of calcium, iron and some other phosphates which are insoluble in water, dissolve in ortho-phosphoric acid. Hence phosphate of iron can be made by the action of phosphoric acid upon iron.

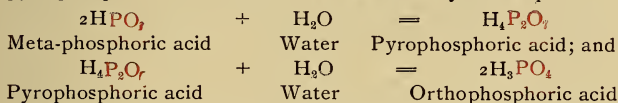The phosphoric acid of the Pharmacopœia is ortho-phosphoric acid.

915. The *officinal phosphates* are all contained in the following

Table of Common Phosphates with their Molecular Formulas and Molecular Weights:

Names.	*Formulas.*	*Molecular Weights.*
Phosphates.		
Hydrogen (ortho-phosphoric acid)	H_3PO_4	98
Potassium	K_2HPO_4	174.2
Sodium	Na_2HPO_4	142
" cryst.	$Na_2HPO_4.12H_2O$	358.1
Microcosmic salt	$NH_4NaHPO_4.4H_2O$	418
Ammonium	$(NH_4)_2HPO_4$	132
Calcium	$Ca_3(PO_4)_2$	310
" Acid	$CaH_4(PO_4)_2$	234
Manganous	$Mn_3(PO_4)_2.7H_2O$	481
Ferrous	$Fe_3(PO_4)_2.8H_2O$	502
Manganic	$Mn_2(PO_4)_3.4H_2O$	425.9
Ferric	$Fe_2(PO_4)_3.4H_2O$	374
Ferroso-ferric	$2Fe_3(PO_4)_3Fe_2(PO_4)_2.24H_2O$	1450.2

916. Metaphosphates.—The so-called "glacial phosphoric acid" is meta-phosphoric acid more or less contaminated with pyrophosphoric acid and with phosphates, as found in commerce.

The relations of meta-phosphoric, ortho-phosphoric and pyro-phosphoric acid to each other are shown by these equations:

$$2HPO_3 \quad + \quad H_2O \quad = \quad H_4P_2O_7$$

Meta-phosphoric acid   Water   Pyrophosphoric acid; and

$$H_4P_2O_7 \quad + \quad H_2O \quad = \quad 2H_3PO_4$$

Pyrophosphoric acid   Water   Orthophosphoric acid

Metaphosphoric acid is changed to orthophosphoric acid by being boiled in water.

Ferric metaphosphate and ferric pyrophosphate are insoluble in ortho-phosphoric acid, but soluble in metaphosphoric acid.

Metaphosphoric acid is $HPO_3 = 80$.

917. Pyrophosphates contain the radical P_2O_7, which acts as a tetrad. Pyrophosphate of sodium is formed when phosphate of sodium is heated strongly; but the pyrophosphate is not decomposed even at extremely high temperatures.

Insoluble pyrophosphates are made by double decomposition from pyrophosphate of sodium.

Crystallized sodium pyrophosphate is $Na_4P_2O_7$,$10H_2O = 446.1$; dried sodium pyrophosphate is $Na_4P_2O_7 = 266$; ferric pyrophosphate is $Fe_4(P_2O_7)_3 = 746$.

Ferric pyrophosphate is insoluble in water, but soluble in diluted metaphosphoric acid; it is also soluble in solutions of alkali citrates, and the pharmacopœial "pyrophosphate of iron" is the water-soluble scaled residue obtained from a solution of ferric pyrophosphate in solution of sodium citrate.

918. Hypophosphites contain the group H_2PO_2 which acts as a monad. The hypophosphites of potassium, sodium, calcium and iron are used as medicines; they are all water-soluble, except that the iron hypophosphites are so sparingly soluble as to be practically nearly insoluble.

Calcium hypophosphite is produced by boiling phosphorus with calcium hydrate; the others are prepared from the calcium hypophosphite or from the sodium salt.

The formulas and molecular weights of the officinal hypophosphites are:

Hypophosphorous Acid $= H\ H_2PO_2 = 66.$
Potassium Hypophosphite $= K\ H_2PO_2 = 104.$
Sodium   " $= Na\ H_2PO_2 = 106.$

Calcium   " $= Ca\ (H_2PO_2)_2 = 170.$

Ferrous   " $= Fe\ (H_2PO_2)_2 = 186.$

Ferric   " $= Fe_2\ (H_2PO_2)_6 = 502.$

CHAPTER LII.

CARBONATES, ETC.

919. **Carbonates** are the salts containing the group CO_3, which is bivalent. They are easily decomposed by acids, the gas CO_2 being given off with effervescence. The carbonates of the alkali metals are the only carbonates not decomposed by heat. Sodium carbonate and potassium carbonate are produced in immense quantities by heating the sulphate with chalk and coal. Insoluble carbonates are prepared from the soluble carbonates by double decomposition.

Acid carbonates are commonly called "bicarbonates." Magnesium, zinc and lead form "basic carbonates."
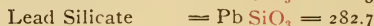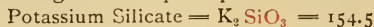
920. *Table of Common Carbonates with their Molecular Formulas and Molecular Weights:*

| Names.	Formulas.	Molecular Weights.
Hydrogen (carbonic acid)	H_2CO_3	62
Potassium, anhydrous	K_2CO_3	138
" ordinary	$2K_2CO_3. 3H_2O$	330
" acid	$KHCO_3$	100
Sodium, anhydous	Na_2CO_3	106
" dried	$Na_2CO_3.2H_2O$	142
" cryst.	$Na_2CO_3 \; 10H_2O$	286
" acid	$NaHCO_3$	84
Lithium	Li_2CO_3	74
Ammonium, normal	$(NH_4)_2CO_3$	96
" acid	NH_4HCO_3	79
" officinal	$NH_4HCO_3 \; NH_4NH_2CO_2$	157
Bismuthyl	$(BiO)_2CO_3 \; H_2O.$	528
Calcium	$CaCO_3$	100
Barium	$BaCO_3$	197
Manganous	$MnCO_3$	115
Ferrous	$FeCO_3. H_2O$	134
Magnesium	$4MgCO_3. Mg(OH)_2 5H_2O$	487.5
Zinc	$2ZnCO_3. 3Zn(OH)_2$	548.5
Lead	$2PbCO_3. Pb(OH)_2$	774.9

921. Borates.—Boric acid is $H_3BO_3 = 62$. No normal borates are used. Borax or "borate of sodium" is a pyroborate, $Na_2B_4O_7.10H_2O = 382.1$. Both boric acid and borax are water-soluble.

922. Silicates contain the radical SiO_3 which is analogous to CO_3 and of the same exchangeable value. The silicates of potassium and sodium are water-soluble; all others insoluble

in water. Solution of sodium silicate is called "water-glass." Flint glass is silicates of lead of potassium; crown glass consists of silicates of sodium and calcium, and Bohemian glass chiefly of silicates of potassium and calcium. The formulas and molecular weights of the principal silicates are:

Potassium Silicate $= K_2 SiO_3 = 154.5$
Sodium Silicate $\quad= Na_2 SiO_3 = 122.3$
Calcium Silicate $\quad= Ca SiO_3 = 116.3$
Lead Silicate $\quad\quad= Pb SiO_3 = 282.7$

923. Arsenates have a structure analogous to that of the phosphates. Ortho-arsenates contain the radical AsO_4 which, like PO_4 is trivalent. Sodium arsenate is an official preparation and is water-soluble; the crystallized sodium arsenate is $Na_2HAsO_4.7H_2O = 312$; the effloresced salt is

$$Na_2H AsO_4 2H_2O = 222;$$
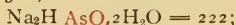
and the dried $Na_2HAsO_4 = 186$. Iron arsenate is sometimes used as a medicine; it is usually of the composition

$$2Fe_3(AsO_4)_2.Fe_2(AsO_4)_2.24H_2O = 1714.2.$$
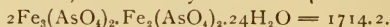
924. Arsenites.—When arsenous oxide is dissolved in water the solution may be regarded as containing arsenous acid,

$$H_3 AsO_3 = 126.$$

Arsenite of potassium is contained in "Fowler's Solution," the salt being $K_2HAsO_3 = 202.2$.

925. Pyro-arsenate of sodium is formed when sodium ortho-arsenate is strongly heated; it is water-soluble and has the formula (dried) $Na_4 As_2O_7 = 368$.

926. Permanganate of potassium, which is so valuable as an oxidizing agent, has the formula $K_2 Mn_2O_8 = 316$ and is soluble in about 16 times its weight of water at ordinary room temperatures.

927. Normal potassium chromate is $K_2 CrO_4 = 194$ and the so-called "bichromate of potassium" is $K_2 Cr_2O_7 = 294$.

CHAPTER LIII.

METALLIC SALTS OF THE ORGANIC ACIDS.

928. Acetates are the salts formed by the acetate radical, $C_2H_3O_2$, which is univalent. All acetates are water-soluble, and they are generally made from acetic acid and the oxides, hydrates or carbonates of metals. Other acetates are made by double decomposition.

929. *The Common Acetates with their Molecular Formulas and Molecular Weights are:*

Names.	Formulas.	Molecular Weights.
Acetates.		
Hydrogen	$H\,C_2H_3O_2$	60
Potassium	$K\,C_2H_3O_2$	98
Sodium	$Na\,C_2H_3O_2$	82
" cryst.	$Na\,C_2H_3O_2 3H_2O$	136
Ammonium	$NH_4\,C_2H_3O_2$	
Magnesium	$Mg\,(C_2H_3O_2)_2$	142.3
Zinc	$Zn\,(C_2H_3O_2)_2$	183
" cryst.	$Zn\,(C_2H_3O_2)_2 3H_2O$	237
Lead	$Pb\,(C_2H_3O_2)_2 3H_2O$	378.4
" basic	$Pb\,(C_2H_3O_2)_2 Pb(OH)_2$	565.4
Copper	$Cu\,(C_2H_3O_2)_2 H_2O$	199.2
Aluminum	$Al_2(OH)_2,\,(C_2H_3O_2)_4$	324
Ferric	$Fe_2\,(C_2H_3O_2)_6$	466

930. Valerates, or "valerianates," contain the radical $C_5H_9O_2$ which is a monad. Those used in medicine and pharmacy are water-soluble.

Valeric acid is	$= H\,C_5H_9O_2$	$= 102$
Sodium Valerate is	$= Na\,C_5H_9O_2$	$= 124$
Ammonium Valerate is	$= NH_4\,C_5H_9O_2$	$= 119$
Zinc Valerate is	$= Zn\,(C_5H_9O_2)_2 H_2O$	$= 285$

931. Lactates contain the radical $C_3H_5O_3$. They are little used.

Lactic Acid $= HC_3H_5O_3$ $= 90$
Sodium Lactate $= NaC_3H_5O_3$ $= 112$
Calcium Lactate $= Ca(C_3H_5O_3)_2$ $= 218$
Zinc Lactate $= Zn(C_3H_5O_3)_2.3H_2O$ $= 297$
Ferrous Lactate $= Fe(C_3H_5O_3)_2.3H_2O$ $= 288$

932. Oleates.—The oleate radical is $C_{18}H_{33}O_2$, which is a monad. Fats, soaps, and lead plaster are the most familiar oleates. All oleates except the *soaps* are insoluble in water. *Soft soap* consists entirely or chiefly of potassium oleate; *hard soaps* contain almost exclusively sodium oleate; the oleates of lead, zinc, iron, copper, and other heavy metals are *plasters*. The liquid fats or fixed oils are mainly oleate of glyceryl.

Oleic acid is made from fats, and all other oleates from either oleic acid or fats.

933. *The Common Oleates are:*

Names.	Formulas.	Molecular Weights.
Hydrogen (oleic acid)	$HC_{18}H_{33}O_2$	282
Potassium	$KC_{18}H_{33}O_2$	320
Sodium	$NaC_{18}H_{33}O_2$	304
Silver	$AgC_{18}H_{33}O_2$	389
Mercurous	$Hg_2(C_{18}H_{33}O_2)_2$	962
Zinc	$Zn(C_{18}H_{33}O_2)_2$	627
Mercuric	$Hg(C_{18}H_{33}O_2)_2$	762
Cupric	$Cu(C_{18}H_{33}O_2)_2$	625
Lead	$Pb(C_{18}H_{33}O_2)_2$	769
Bismuth	$Bi(C_{18}H_{33}O_2)_3$	105
Aluminum	$Al_2(C_{18}H_{33}O_2)_6$	174
Ferric	$Fe_2(C_{18}H_{33}O_2)_6$	179

934. Oxalates are salts of the oxalate radical C_2O_4 Oxalic acid is bibasic.

The oxalates of potassium sodium and ammonium are water-soluble, and made by neutralizing oxalic acid with the alkali hydrates or carbonates; all other oxalates are insoluble and made by precipitation.

Oxalic acid is probably the "strongest" of the organic acids.

No oxalates, except the cerium and ferrous, are official, but several are officinal.

Oxalic acid	$= H_2C_2O_4$	$= 90$
" " with water	$= H_2C_2O_4 \cdot 2H_2O$	$= 126$
Potassium oxalate, normal	$= K_2C_2O_4 \cdot 2H_2O$	$= 202$
" " acid	$= KHC_2O_4 \cdot 2H_2O$	$= 162$
Ammonium "	$(NH_4)_2C_2O_4 H_2O$	$= 142$
Cerium "	$Ce_2(C_2O_4)_3 9H_2O$	$= 706$
Ferrous "	$FeC_2O_4 \cdot H_2O$	$= 162$

935. Tartrates.—The tartrate radical is $C_4H_4O_6$, and it acts as a dyad. Acid tartrate of potassium is contained in the juice of grapes and other fruits. In the crude, impure state the potassium acid tartrate is called "argols," or "crude tartar;" and the pure is called "cream of tartar," or "bitartrate of potassium." All other tartrates are made from the acid tartrate of potassium, directly or indirectly. Acid tartrate of potassium is only sparingly soluble in water, requiring about 200 times its own weight of water at ordinary room temperatures; the acid tartrates of sodium and ammonium are also sparingly soluble. The acid tartrates form soluble compounds with iron, of which the official tartrate of iron and potassium and tartrate of iron and ammonium are examples.

936. *The common tartrates are:*

Names.	Formulas.	Molecular Weights.
Hydrogen (tartaric acid)	$H_2C_4H_4O_6$	150
Potassium, normal	$K_2C_4H_4O_6$	226
" acid	$KHC_4H_4O_6$	188
(cream of tartar)		
Rochelle salt	$KNaC_4H_4O_6 \cdot 4H_2O$	282
Sodium, normal	$Na_2C_4H_4O_6 \cdot 2H_2O$	230
" acid	$NaHC_4H_4O_6 \cdot H_2O$	190
Ammonium, normal	$(NH_4)_2C_4H_4O_6$	184
" acid	$NH_4HC_4H_4O_6$	167
Potassium Antimonyl ("Tartar Emetic")	$2KSbOC_4H_4O_6 \cdot H_2O$	664
Magnesium	$MgC_4H_4O_6$	172

937. Citrates are the salts formed by the radical $C_6H_5O_7$, which is trivalent. There are, therefore, three kinds of citrates (897). Citric acid is contained in various fruit juices, especially those of lemons, limes and currants. Other citrates are prepared from citric acid. The citrates are generally water-soluble. The water solutions of alkali citrates dissolve ferric phosphate, pyrophosphate and hypophosphite, all of which are insoluble in water. Bismuth citrate is soluble in ammonia water.

938. *The most common citrates are:*

Names.	Formulas.	Molecular Weights.
Hydrogen (Citric Acid)	$H_3C_6H_5O_7 \cdot H_2O$	210
Potassium, normal	$K_3C_6H_5O_7 \cdot H_2O$	324
Di-Potassium Hydrogen	$K_2HC_6H_5O_7$	286
Potassium Di-Hydrogen	$KH_2C_6H_5O_7$	248
Sodium, normal	$Na_3C_6H_5O_7$	258

Names.	Formulas.	Molecular Weights.
Di-Sodium Hydrogen	$Na_2HC_6H_5O_7$	236
Sodium Di-Hydrogen	$NaH_2C_6H_5O_7$	214
Ammonium, normal	$(NH_4)_3C_6H_5O_7$	243
Di-Ammonium Hydrogen	$(NH_4)_2HC_6H_5O_7$	226
Ammonium Di-Hydrogen	$NH_4H_2C_6H_5O_7$	209
Lithium, normal	$Li_3C_6H_5O_7$	210
Magnesium, normal	$Mg_3(C_6H_5O_7)_2$	450.9
" acid	$MgHC_6H_5O_7$	214.3
Ferric	$Fe_2(C_6H_5O^7)_2.6H_2O$	598.1
" anhydrous	$Fe_2(C_6H_5O^7)_2$	490
Bismuth	$BiC_6H_5O_7$	398

939. **Phenolsulphonates** are salts containing the complex radical $C_6H_5SO_4$. [Ortho-sulphonic acid is $C_6H_4.OH.HSO_3$.] The phenolsulphonates used in medicine and pharmacy are commonly called "sulphocarbolates." We have phenolsulphonates of—

$$\text{Sodium} = NaC_6H_5SO_4.2H_2O = 232$$
$$\text{Calcium} = Ca(C_6H_5SO_4)_2. = 386$$
$$\text{Barium} = Ba(C_6H_5SO_4)_2. = 483$$
$$\text{Zinc} = Zn(C_6H_5SO_4)_2.8H_2O = 555$$

940. **Salicylates** contain the acid radical $C_7H_5O_3$. The salicylates used in medicine are all made from salicylic acid or from salicylate of sodium. Salicylic acid is made from phenol (commonly called "carbolic acid"). The volatile oil of wintergreen contains 90 per cent. of methyl salicylate. The alkali salicylates are readily water-soluble, and salicylate of zinc moderately soluble, while salicylic acid is nearly insoluble.

The common salicylates are:

$$\text{Salicylic Acid} = HC_7H_5O_3 = 138$$
$$\text{Sodium Salicylate} = 2NaC_7H_5O_3.H_2O = 338$$
$$\text{Lithium} \quad " \quad = 2LiC_7H_5O_3.H_2O = 306$$
$$\text{Zinc} \quad " \quad = Zn(C_7H_5O_3)_2.3H_2O = 393$$
$$\text{Bismuth} \quad " \quad = Bi(C_7H_5O_3)_3 = 620$$
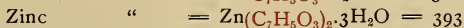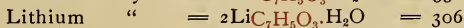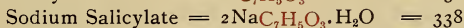
941. **Benzoates.**—The acid-radical of the benzoates is $C_7H_5O_2$. Benzoic acid occurs in benzoin, and is also produced synthetically from toluol, etc. The benzoates of sodium, lithium and ammonium are used medicinally; they are all water-soluble and prepared from benzoic acid and the respective alkali carbonates.

The formulas are :

Benzoic acid		$H C_7H_5O_2$	$= 122.$
Potassium Benzoate		$K C_7H_5O_2$	$= 160.$
Sodium	"	$Na C_7H_5O_2, H_2O$	$= 162.$
Lithium	"	$Li C_7H_5O_2$	$= 128.$
Ammonium	"	$NH_4 C_7H_5O_2$	$= 139.$
Calcium	"	$Ca(C_7H_5O_2)_2$	$= 282.$
Ferric	"	$Fe_2(C_7H_5O_2)_6$	$= 838.$

CHAPTER LIV

HYDROCARBONS.

942. **Hydrocarbons.**—The hydrocarbons are compounds of only the two elements, carbon and hydrogen. Hundreds of them are already known, and numerous others are possible.

The hydrocarbon molecules may contain any number of carbon atoms, from one up to at least thirty-five. In all hydrocarbons containing more than one carbon atom, all the carbon atoms present are, of course, united by a portion of their bonds into a continuous chain or ring, or cluster, while all of the hydrogen atoms are united to the remaining carbon bonds.
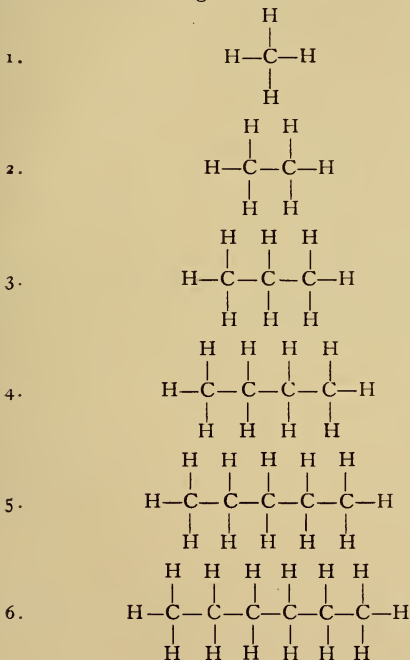
943. As carbon is a tetrad it follows that the highest proportion of hydrogen that can unite with carbon is present in the compound CH_4, called **methane** (commonly called " marsh-gas").

944. All hydrocarbons may be arranged into several different series, each series represented by one *general formula,* and

the several members of each series differing from each other by the group CH_2 or a multiple of it.

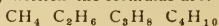Such series are called *homologous series.*

945. The first series, or methane series, of hydrocarbons begins with the following members:

1.
$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

2.
$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

3.
$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

4.
$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

5.
$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

6.
$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$
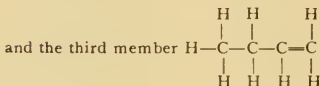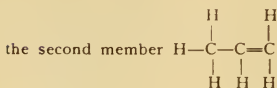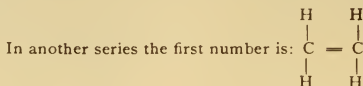
It will be seen that for every additional carbon atom there must be two additional hydrogen atoms. This explains why it is that each member of the series differs from the preceding member by CH_2.

946. If you examine the formulas just presented you will find that this whole series may well be represented by the general formula: $H(CH_2)nH$, for

every member of the series consists of any number of groups of CH_2 linked together by their carbon bonds and the chain united to a hydrogen atom at each end. As commonly written the formulas are:

$$CH_4 \quad C_2H_6 \quad C_3H_8 \quad C_4H_{10}$$

and so on.

In another series the first number is:

$$\begin{array}{ccc} H & & H \\ | & & | \\ C & = & C \\ | & & | \\ H & & H \end{array}$$

the second member

$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}=\overset{\displaystyle H}{\underset{\displaystyle H}{C}}$$

and the third member

$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}=\overset{\displaystyle H}{\underset{\displaystyle H}{C}}$$

For this the general formula $(CH_2)n$ might be assigned.

947. But the general formulas for the homologous series of hydrocarbons are usually expressed as follows:

Series			Lowest member known,		
1.	CnH_2n+2				CH_4
2.	CnH_2n		"	"	C_2H_4
3.	CnH_2n-2		"	"	C_2H_2
4.	CnH_2n-4		"	"	C_6H_6
5.	CnH_2n-6		"	"	C_6H_6
6.	CnH_2n-8		"	"	C_8H_8
7.	CnH_2n-10		"	"	C_8H_6
8.	CnH_2n-12		"	"	$C_{10}H_8$
9.	CnH_2n-14		"	"	$C_{12}H_{10}$
10.	CnH_2n-16		"	"	$C_{14}H_{12}$
11.	CnH_2n-18		"	"	$C_{14}H_{10}$
12.	CnH_2n-20		"	"	$C_{17}H_{14}$
13.	CnH_2n-22		"	"	$C_{16}H_{10}$
14.	CnH_2n-24		"	"	$C_{18}H_{12}$
15.	CnH_2n-26		"	"	$C_{20}H_{14}$
16.	CnH_2n-28		"	"	————
17.	CnH_2n-30		"	"	$C_{22}H_{14}$
18.	CnH_2n-32		"	"	$C_{26}H_{20}$

In these general formulas the italic letter *n* means *any number*. Thus the general formula for Series 1, written CnH_2n+2 means: any number of carbon atoms united with twice the same number plus two of hydrogen atoms;

the general formula for Series 2, written CnH_2n means: any number of carbon atoms united to twice the same number of hydrogen atoms; the general formula for Series 3, written $CnH_2n—2$ means: any number of carbon atoms united to twice the same number less 2 of hydrogen atoms; etc.

948. Knowing the number of carbon atoms in any member of any one of these series we can write its molecular formula in accordance with the general formula for its series; thus the member of Series 1 having 12 carbon atoms must be $C_{12}H_{26}$; of Series 2 it would be $C_{12}H_{24}$; of Series 3, $C_{12}H_{22}$; of Series 4, $C_{12}H_{20}$; of Series 5, $C_{12}H_{18}$; of Series 9, $C_{12}H_{10}$; of Series 14 there could be no member with but twelve carbon atoms, and of Series 10 to 13 none are known having twelve atoms of carbon.

949. Hydrocarbons are generally *gaseous* when containing less than four atoms of carbon; *liquid* if containing more than four but less than twelve carbon atoms; *solid* if they contain a higher number of atoms of carbon.

950. According to the properties of their derivatives, the hydrocarbons are divided into two series—the *fatty series* and the *aromatic series*. Fats or fixed oils belong to the derivatives of the fatty series of hydrocarbons, and the aromatic acids and other aromatic or odorous compounds are derivatives of the aromatic series.

951. Marsh gas, CH_4, is a colorless and tasteless gas, which is generated in swamps by the decay of organic matter; it is the principal constituent of the so-called "natural gas," and in coal mines it exists as "fire-damp."

952. Hydrocarbons occur in coal oils, paraffines, petrolatum, paraffin oil, illuminating gas, natural gas, oil of turpentine, oil of lemon and many other volatile oils, etc.

Among the common hydro-carbons are:

Paraffin $= C_{16}H_{34}$.
Benzin $= C_5H_{12}$ and C_6H_{14}.
Turpenes $= (C_{10}H_{16})n$.
Benzene $= C_6H_6$.

953. Among the derivatives or substitution products of hydro-carbons are:

Chloroform, $CHCl_3$, which is tri-chlor-methane.
Iodoform, CHI_3, which is tri-iodo-methane.

The **haloids** of the hydro-carbon radicals correspond to the chlorides, bromides, iodides and cyanides of the metals. Thus, trichlormethane may be regarded as formyl chloride, or the chloride of the radical CH. Haloids of methyl (CH_3), ethyl (C_3H_5) and other positive organic compound radicals (263) are well-known.

954. Hydrocarbon Radicals are groups of carbon and hydrogen atoms having free carbon bonds.

When a hydrogen atom is removed from a hydro-carbon molecule, the remainder constitutes a positive radical with one valence unit; for every additional hydrogen atom removed another valence unit is added to the radical. Thus, if we take one hydrogen atom from CH_4, we have the radical CH_3 left, which is univalent; the removal of two hydrogen atoms would leave the radical CH_2 with two free bonds; and if still another hydrogen atom be removed, we get the trivalent radical CH.

955. The hydrocarbons (942) may be regarded as the hydrides of the hydrocarbon radicals. Thus Methane, CH_4, can be looked upon as the hydride of methyl, CH_3H; ethane, C_2H_6, as ethyl hydride, C_2H_5H, etc.

956. Hydrocarbon radicals, in fact, form the same classes of compounds as are formed by metals, namely, oxides, sulphides, chlorides, bromides, iodides, cyanides, bases and salts. Their oxides are called ethers, their hydrates are alcohols, and the salts they form with the acids are called ethereal salts.

CHAPTER LV.

OTHER IMPORTANT CLASSES OF ORGANIC COMPOUNDS.

957. **Alcohols.**—The alcohols of organic chemistry correspond to the metallic hydrates of inorganic chemistry. They all contain hydroxyl, HO, which is united to the hydrocarbon radical just as the hydroxyl in a metallic hydrate or base is united to the metal.

There are three classes of alcohols, namely, *primary*, *secondary* and *tertiary* alcohols.

958. *Primary alcohols* all have the general formula $H(CH_2)n$ OH; that is, they all contain the two groups, CH_2 and OH.

When oxidized the primary alcohols yield first aldehydes, and then acids, containing the same number of carbon atoms.

959. *Secondary alcohols* all contain the two groups, CH and OH.

When subjected to the action of oxidizing agents they form acetones; and, upon further oxidation, acids containing a smaller number of carbon atoms.

960. *Tertiary alcohols* all contain C.OH.

When oxidized they form neither aldehydes nor acetones, but are directly converted into acids having a smaller number of carbon atoms.

961. Any organic compound containing hydroxyl of which the hydrogen can be replaced by an acid-radical, is an alcohol. If this alcohol yields aldehyde when oxidized, and then an acid, it is a primary alcohol; if its oxidation results in acetone and subsequently acid, it is a secondary alcohol; and if upon oxidation it splits up, yielding an acid without first forming an aldehyde or an acetone, it is a tertiary alcohol.

962. The simplest primary alcohol is methyl alcohol, CH_3 OH (commonly called wood alcohol, or wood spirit). If two of the hydrogen atoms of the group CH_3 in that alcohol be replaced by hydrocarbon radicals, the resulting products are secondary alcohols; if all three of the hydrogen atoms of the methyl group are replaced by hydrocarbon radicals, tertiary alcohols result.

963. It will be seen that the characteristic alcohol groups differ from each other by one or two hydrogen atoms, since

<div style="text-align:center">

Primary alcohols contain CH_2OH
Secondary   "   " $CH.OH$
Tertiary   "   " $C.OH$

</div>

964. Alcohols containing but one hydroxyl group are sometimes called *monatomic alcohols*, while those containing two hydroxyl groups are called *diatomic alcohols*, and alcohols with three hydroxyl groups are called *triatomic alcohols*. A monatomic alcohol is, of course, the hydrate of a univalent hydrocarbon radical; a diatomic alcohol is the hydrate of a bivalent hydrocarbon radical; and trivalent hydrocarbon radicals must furnish triatomic alcohols.

965. Among the alcohols the following are familiar:

<div style="text-align:center">

Methyl alcohol, or wood spirit $= CH_3OH.$
Ethyl alcohol, or ordinary alcohol $= C_2H_5OH.$
Amyl alcohol, or fusel oil $= C_5H_{11}OH.$
Phenyl alcohol, or "carbolic acid" $= C_6H_5OH.$
Glyceryl alcohol, or "glycerin" $= C_3H_5(OH)_3.$

</div>

Ethyl alcohol is formed by the fermentation of glucose (1102):

$$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2$$
<div style="text-align:center">Glucose   Alcohol   Carbon dioxide</div>

966   Mercaptans are compounds analogous to the alcohols in general structure, but containing HS instead of HO. They are, then, hydrosulphides of hydrocarbon radicals.

967.   Aldehydes.—When primary alcohols are oxidized in a limited supply of oxygen they are transformed into *aldehydes* by the removal of hydrogen. The name is coined out of the words *al*cohol *dehyd*rogenated. The hydrogen thus removed is oxidized to water.

It was stated (958) that the characteristic group contained in primary alcohols is $CH_2.OH$; when the alcohol is changed to an aldehyde, that group is converted into $CO.H$ or $O=C—H$, which is a univalent group.

Common aldehyde is CH_3 $CO.H$.

There are no aldehydes corresponding to the secondary and tertiary alcohols.

968.   Ketones or acetones are formed by the incomplete oxidation of secondary alcohols (959).

Secondary alcohols contain the characteristic group $CH.OH$; this becomes CO when a ketone is formed. The group CO, carbonyl, is bivalent, and in the formation of ketones or acetones both of the free carbon bonds of the carbonyl unite with hydrocarbon radicals. The simplest ketone is $CH_3.CO.CH_3$.

969.   Organic Acids are formed by the complete oxidation of alcohols. They all contain hydroxyl and correspond in their general chemical properties to the inorganic hydroxyl acids. But all organic acids contain, besides *hydroxyl*, the group CO, called *carbonyl*. The two groups, CO and OH have been written together as CO_2H. or $CO.OH$, and called by one name, *carboxyl*. The simplest organic acid known is $H.CO.OH$, which is called formic acid. The next member of the same series of acids is acetic acid $= CH_3.CO.OH$.

970.   The general formula for the series of organic acids corresponding to the methane series of hydrocarbons and the primary alcohols of the hydrocarbon radicals of the same series, is $H(CH_2)_n CO.OH$. Thus we have:

Formic Acid $= HCO.OH$
Acetic Acid $= HCH_2.CO.OH$
Propionic Acid $= H(CH_2)_2.CO.OH$

$$Butyric\ Acid = H(CH_2)_3.CO.OH$$
$$\mathbf{Valeric\ Acid} = H(CH_2)_4.CO.OH$$
$$Myristic\ Acid = H(CH_2)_{13}.CO.OH$$
$$Palmitic\ Acid = H(CH_2)_{15}.CO.OH$$
$$Stearic\ Acid = H(CH_2)_{17}.CO.OH$$

The acids included in the preceding table are all monobasic acids.

Lactic Acid, which belongs to a different series is monobasic and has the formula

$$H.CH_2.CH(OH).CO.OH., \text{ or}$$

$$
\begin{array}{l}
H\text{---}CH_2 \\
\quad | \\
HO\text{---}CH \qquad or \qquad HC_3H_5O_3 \\
\quad | \\
\quad CO \\
\quad | \\
\quad OH
\end{array}
$$
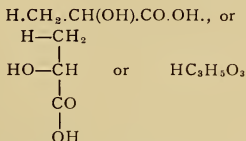
Oleic Acid is $HC_{18}H_{33}O_2$
Salicylic Acid is $HC_7H_5O_3$
Benzoic Acid is $HC_7H_5O_2$
Gallic Acid is $HC_7H_5O_5$

971. Among the *bibasic organic acids* are:

Oxalic Acid,

$$HO.OC.CO.OH., \text{ or}$$

$$
\begin{array}{l}
OH \\
| \\
CO \qquad or \qquad (CO.OH)^2 \\
| \\
CO \qquad or \qquad H^2C^2O_4 \\
| \\
OH
\end{array}
$$

Tartaric Acid is:

$$
\begin{array}{l}
OH \\
| \\
CO \\
| \\
HO\text{---}CH \qquad or \qquad H_2C_4H_4O_6 \\
| \\
HO\text{---}CH \qquad or \qquad (CH.OH)_2(CO.OH)^2 \\
| \\
CO \qquad or \qquad (CH.OH.CO.OH)_2 \\
| \\
OH
\end{array}
$$

Succinic Acid is:

$$
\begin{array}{l}
\text{OH} \\
| \\
\text{CO} \\
| \\
\text{CH}_2 \\
| \\
\text{CH}_2 \\
| \\
\text{CO} \\
| \\
\text{OH}
\end{array}
\qquad
\begin{array}{l}
\text{or} \\
\\
\text{or} \\
\\
\text{or}
\end{array}
\qquad
\begin{array}{l}
H_2C_4H_4O_4 \\
\\
(CH_2)_2(CO.OH)_2 \\
\\
(CH_2.CO.OH)_2
\end{array}
$$
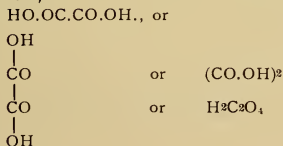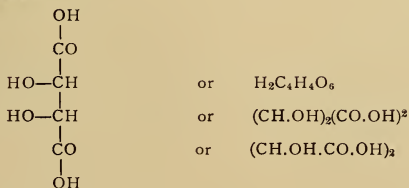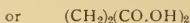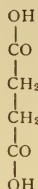
972. Among the *tribasic acids* are:

Citric Acid,

$$
\begin{array}{l}
\text{OH} \\
| \\
\text{CO} \\
| \\
\text{CH}_2 \\
| \\
\text{HO}-\text{C}-\!-\!\text{CO} \\
\quad | \quad\; | \\
\text{CH}_2\; \text{OH} \\
| \\
\text{CO} \\
| \\
\text{OH}
\end{array}
\qquad
\begin{array}{l}
\text{or } (CH_2)_2.C.OH.(CO.OH)_3, \\
\text{or } H_3C_6H_5O_7.
\end{array}
$$

Malic Acid,

$$
\begin{array}{l}
\text{O}-\text{H} \\
| \\
\text{CO} \\
| \\
\text{HO}-\text{CH} \\
| \\
\text{CH} \\
| \\
\text{CO} \\
| \\
\text{OH}
\end{array}
\qquad
\begin{array}{l}
\text{or } CH_2.CHOH.(CO.OH)_2, \\
\text{or } H_3C_4H_3O_5.
\end{array}
$$
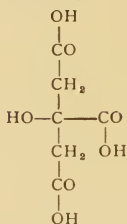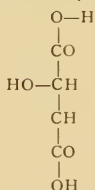
973. **Ethers.**—The oxides of hydrocarbon radicals (or "hydrocarbon residues") are called *ethers*, or "simple ethers." The most common simple ethers are ethyl oxide, which is the ether of the Pharmacopœia, and methyl oxide:

$$\begin{matrix} CH_3 \searrow \\ \qquad O \\ CH_3 \nearrow \end{matrix} \quad \text{and} \quad \begin{matrix} C_2H_5 \searrow \\ \qquad O, \text{ or} \\ C_2H_5 \nearrow \end{matrix}$$

$(CH_3)_2O$ and $(C_2H_5)_2O$

Methyl ether **Ethyl ether.**
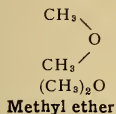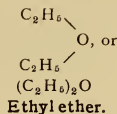
974. Ethereal Salts, or *Compound Ethers.*—These are the salts formed by the positive hydrocarbon radicals with the inorganic and organic acid radicals. These ether salts are also called *esthers.*

They are formed when acids and organic hydroxides (alcohols) act upon each other, just as metallic salts are formed when acids and metallic bases act upon each other.

Thus we have among the most common ethereal salts the fats or fixed oils, composed mainly of the oleate, palmitate and stearate of glyceryl; the delicious flavors of certain fruits are also compound ethers (amyl acetate has the flavor of pears; the flavor of apples is due to amyl valerate; pine-apple flavor is chiefly due to ethyl butyrate, and combinations of the acetates, valer-ates and butyrates of ethyl and amyl produce flavors resembling those of many fruits), and the pharmacopœia contains preparations of the nitrates of amyl and ethyl, and acetate of ethyl, while oil of wintergreen is salicylate of methyl.

Methyl acetate is $CH_3 C_2H_3O_2$	Ethyl acid sulphate is $C_2H_5.HSO_4$
Methyl salicylate is $CH_3.C_7H_5O_3$	Ethyl acetate is $C_2H_5.C_2H_3O_2$
Ethyl nitrite is $C_2H_5.NO_2$	Ethyl benzoate is $C_2H_5.C_7H_5O_2$
Ethyl nitrate is $C_2H_5 NO_3$	Amyl nitrite is $C_5H_{11}.NO_2$

Glyceryl oleate (olive oil) is $C_3H_5.C_{18}H_{33}O_2$

975. *Recapitulation.*—The constitution of the hydrocarbon radicals of the methyl series and their compounds may be shown by the following general formulas:

Radicals of the methyl series	$= H(CH_2)_n$
Hydrocarbons of the methane series	$= H(CH_2)_n H$
Oxides or simple ethers	$= \begin{cases} H(CH_2)_n \searrow \\ \qquad\qquad O \\ H(CH_2)_n \nearrow \end{cases}$
Chlorides	$= H(CH_2)_n Cl$
Bromides	$= H(CH_2)_n Br$
Iodides	$= H(CH_2)_n I$
Alcohols, or hydrates	$= H(CH_2)OH$
Aldehydes	$= H(CH_2)_n CO H$
Ketones, or acetones	$= H(CH_2)_n .CO.(CH_2)_n H$
Ethereal salts	$= H(CH_2)_n.CO.OH(CH_3)_n$

Radicals:—

$$HCH_2 \quad = Methyl$$
$$H(CH_2)_2 \quad = Ethyl$$
$$H(CH_2)_3 \quad = Propyl$$
$$H(CH_2)_4 \quad = Butyl$$
$$H(CH_2)_5 \quad = Amyl$$
$$H(CH_2)_6 \quad = Hexyl$$

etc.

Hydrocarbons:—

$$HCH_2H \quad = Methane$$
$$H(CH_2)_2H = Ethane$$
$$H(CH_2)_3H = Propane$$
$$H(CH_2)_4H = Butane$$
$$H(CH_2)_5H = Pentane$$
$$H(CH_3)_6H = Hexane$$

etc.

Ethers:—

$$\left. \begin{array}{c} HCH_2 \\ HCH_2 \end{array} \right\rangle O = Methyl\ Oxide$$

$$\left. \begin{array}{c} H(CH_2)_2 \\ H(CH_2)_2 \end{array} \right\rangle O = Ethyl\ Oxide$$

$$\left. \begin{array}{c} H(CH_2)_3 \\ H(CH_2)_3 \end{array} \right\rangle O = Propyl\ Oxide$$

$$\left. \begin{array}{c} H(CH_2)_4 \\ H(CH_2)_4 \end{array} \right\rangle O = Butyl\ Oxide$$

$$\left. \begin{array}{c} H(CH_2)_5 \\ H(CH_2)_5 \end{array} \right\rangle O = Pentyl\ Oxide$$

etc.

Alcohols:—

$$HCH_2OH \quad = Methyl\ alcohol$$
$$H(CH_2)_2OH = Ethyl\ alcohol$$
$$H(CH_2)_3OH = Propyl\ alcohol$$
$$H(CH_2)_4OH = Butyl\ alcohol$$
$$H(CH_2)_5OH = Amyl\ alcohol$$

etc.

Aldehydes:—

$$H.CO.H \quad\quad = Formic\ aldehyde$$
$$H.CH_2.CO.H \quad = Common\ aldehyde$$

$$H.(CH_2)_2.CO.H = \text{Propyl aldehyde}$$
$$H.(CH_2)_3.CO.H. = \text{Butyl aldehyde}$$
$$H.(CH_2)_4.CO.H. = \text{Amyl aldehyde}$$
<div align="center">etc.</div>

Acetones:—

$$H.CO.CH_2.H$$
$$H.CH_2.CO.CH_2H.$$
$$H.(CH_2)_2.CO.CH_2.H.$$
$$H.(CH_2)_3.CO.CH_2.H.$$

<div align="center">or—</div>

$$\left.{HCH_2 \atop HCH_2}\right\rangle CO$$
$$\left.{H(CH_2)_2 \atop H(CH_2)_2}\right\rangle CO$$
$$\left.{H(CH_2)_3 \atop H(CH_2)_3}\right\rangle CO.$$

Acids:—

$$H.CO.OH. = \text{Formic acid}$$
$$H.CH_2.CO.OH = \text{Acetic acid}$$
$$H(CH_2)_2.CO.OH = \text{Propionic acid}$$
$$H(CH_2)_3.CO.OH = \text{Butyric acid}$$
$$H(CH_2)_4.CO.OH = \text{Valeric acid}$$
<div align="center">etc.</div>

976. Carbohydrates are compounds containing carbon, hydrogen and oxygen, and no other elements, the carbon atoms being six in number or a multiple of six, while the hydrogen atoms present are twice as many as the oxygen atoms present.

The word "carbohydrate" is based upon the general constitution just described, which suggested to the originator of the term carbohydrate that these substances might be likened to hydrates of carbon. The formula $C_6H_{10}O_5$ looks like six atoms of carbon and five molecules of water, $C_{12}H_{22}O_{11}$ looks like twelve carbon atoms and eleven molecules of water, and hydrates were formerly considered as compounds containing water. But the hydrogen and oxygen in carbohydrates are not combined into water molecules, nor can carbon combine with water, so that the name is confusing.

The principal classes of carbohydrates are as follows:

Cellulose Group	*Saccharose Group*	*Glucose Group*
$(C_6H_{10}O_5)_n$	$C_{12}H_{22}O_{11}$	$C_6H_{12}O_6$
Cellulose	Cane Sugar	Grape Sugar
Starch	Milk Sugar	Fruit Sugar
Dextrin	Maltose	
Gums	Melitose	

977. **Glucosides** are complex bodies, sometimes having weak acid properties, sometimes neutral, which are split up under the influence of dilute acids, ferments, etc., especially with the aid of heat, yielding, as one of the decomposition products, sugar of the glucose group.

Many of the *neutral principles* of plants are *glucosides*.

Salicin, santonin, and amygdalin are examples of glucosides.

978. **Alkaloids** are organic compounds resembling ammonia in that they contain nitrogen, have an alkaline reaction on test-paper, and are capable of neutralizing acids with which they combine to form salts. The chemical structure of alkaloids is not yet clearly understood.

Alkaloids occur in many plants of decided medicinal potency. Most of them are so powerful in their effects upon the animal organism as to be poisonous, but some of the alkaloids appear to be simply bitter tonics.

Among the common alkaloids are *quinine, morphine, strychnine, veratrine, atropine, codeine, caffeine, cocaine.*

By far the greater number of the alkaloids are solids, inodorous, bitter or acrid, non-volatile, and contain in their molecule carbon, hydrogen and oxygen as well as nitrogen. These are called *amides*, or *quaternary alkaloids*.

Other alkaloids contain only carbon, hydrogen and nitrogen; these are called *amines*, or *ternary alkaloids*, and are liquid, volatile, and strongly odorous. The only common volatile alkaloids are *nicotine*, which is contained in tobacco; *coniine*, in conium; and *lobeline*, in lobelia.

When alkaloids combine with acids to form salts they behave exactly as ammonia does in that they unite with the whole acid-molecule, including its hydrogen, thus:

$$NH_3 \quad + \quad HNO_3 \quad = \quad NH_4NO_3$$
Ammonia,   Nitric Acid,   Ammonium Nitrate,

$$NH_3 \quad + \quad HCl \quad = \quad NH_4Cl$$
Ammonia,   Hydrochloric Acid,   Ammonium Chloride,

$$NH_2CH_3 \quad + \quad HNO_3 \quad = \quad NH_2CH_3HNO_3$$
Methylamine,   Nitric Acid,   Methylamine Nitrate,

$$2C_{21}H_{22}N_2O_2 \quad + \quad H_2SO_4 \quad = \quad (C_{21}H_{22}N_2O_2)_2H_2SO_4$$
Strychnine,   Sulphuric Acid,   Strychnine Sulphate,

$$C_{20}H_{24}N_2O_2 \quad + \quad HCl \quad = \quad C_{20}H_{24}N_2O_2HCl$$
Quinine,   Hydrochloric Acid,   Quinine Hydrochlorate.
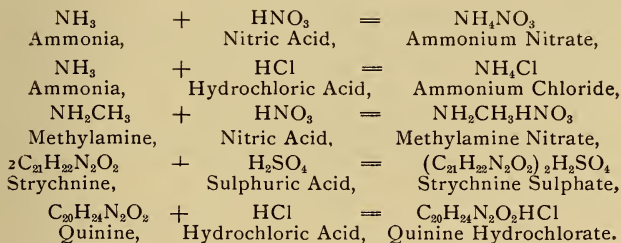
CHAPTER LVI.

CHEMICAL NOMENCLATURE.

979. The names of chemical compounds are generally constructed out of the names of the constituent radicals so far as practicable. When, however, the molecule is complex and several different molecules contain the same elements that plan is impracticable, and the technical names given to such compounds are based upon their internal structure, source, or properties, or upon other facts or conditions. Some names in common use are entirely arbitrary and unscientific, and have mostly been transmitted from early times.

980. The technical names of chemicals usually consist of two parts.

Whenever the name of a chemical compound is derived from the radicals which enter into it, then the first part of the name is derived from or consists of the name of the positive radical, while the second part is derived from the negative radical.

Thus we say silver oxide, potassium chloride, mercuric iodide, sulphur dioxide, calcium sulphide, copper nitrate, ethyl nitrite, magnesium sulphate, magnesium sulphite, etc.

981. Binary compounds (844) and many other compounds consisting of two radicals directly united have generic names ending with *–ide* and derived from their respective negative radicals.

Thus compounds consisting of positive radicals (elemental or compound) directly united to oxygen are called oxides; when the positive radical is united to sulphur the compound is called a sulphide, etc.   If we designate the positive radical by the letter $\overset{+}{R}$, then

$\overset{+}{R}O$ = oxide.

$\overset{+}{R}S$ = sulphide.

$\overset{+}{R}Cl$ = chloride.

$\overset{+}{R}I$ = iodide.

$\overset{+}{R}Br$ = bromide.

$\overset{+}{R}CN$ = cyanide.

$\overset{+}{R}H$ = hydride.

$\overset{+}{R}P$ = phosphide.

$\overset{+}{R}Se$ = selenide.

$\overset{+}{R}CH_3$ = methylide.

$\overset{+}{R}N$ = nitride, etc.

982. But it often happens that two or more different compounds are formed by the same two radicals. There are five different oxides of nitrogen ; five oxides of manganese ; four oxides of chlorine ; three sulphides of arsenic ; two chlorides of iron or of mercury, etc.

[The fact that any two radicals may form more than one compound by combining in more than one proportion is explained on the assumption that many of the elements have a variable valence, as explained elsewhere. Sometimes this assumption seems unnecessary, as in the case of the oxides of nitrogen and chlorine, which may be represented by chains : N—O—N, N—O—O—N, Cl—O—Cl, Cl—O—O—O—Cl, etc.; but in other cases no explanation seems possible except that afforded by the assumption of *variable valence* (617 to 619).]

983. Different names must, of course, be given to these different compounds in order to distinguish them from each other. The simplest method, and, therefore, the best, is to prefix the Greek numerals to the second part of the name, to indicate the number of times the negative radical is multiplied.

The oxides of nitrogen all contain two atoms of nitrogen and 1, 2, 3, 4 or 5 atoms of oxygen. They are, accordingly, represented by the following names and formulas:

> Nitrogen monoxide, N_2O.
> Nitrogen dioxide, N_2O_2.
> Nitrogen trioxide, N_2O_3.
> Nitrogen tetroxide, N_2O_4.
> Nitrogen pentoxide, N_2O_5.

This system is very explicit, and might .advantageously be employed to a greater extent than it is.

984. In some cases, however, this method of numeral prefixes (983) in connection with the negative radicals is not applicable as, for instance, in compounds of mercury which contain the same number of atoms of the negative element but different numbers of atoms of the positive element.

985. A still more explicit method is to prefix numerals to both of the radicals. Thus we might say di-nitrogen monoxide, di-nitrogen di-oxide, di-nitrogen tri-oxide, etc. But this would seem to be superfluous in the naming of the nitrogen oxides, because all of them contain two nitrogen atoms.

986. In naming certain compounds of polyvalent radicals the use of numerals as prefixes is the most convenient as well as explicit method. Thus we would distinguish normal sodium phosphate Na_3PO_4, from Na_2HPO_4 and NaH_2PO_4 as follows:

$Na_3PO_4 =$ tri-sodium phosphate, or normal sodium phosphate.
$Na_2HPO_4 =$ di-sodium hydrogen phosphate.
$NaH_2PO_4 =$ sodium di-hydrogen phosphate.

In a similar manner we might call water di-hydrogen monoxide, and the so-called peroxide of hydrogen, H_2O_2, might be called di hydrogen dioxide.

NH_2CH_3 is mono-methyl amine; $NH(CH_3)_2$ is di methyl amine; and $N(CH_3)_3$ is tri-methyl amine.

In organic chemistry the use of numeral prefixes is invaluable, as may be seen in the following:

Ethylene diamine	$= C_2H_4(NH_2)_2$
Diethylene diamine	$= N_2(C_2H_4)_2H_2$
Triethylene diamine	$= N_2(C_2H_4)_3$
Diethylene triamine	$= N_3(C_2H_4)_2H_5$
Triethylene triamine	$= N_3(C_2H_4)_3H_3$
Triethylene tetramine	$= N_4(C_2H_4)_3H_6$

987.   The numeral prefixes of Greek origin are:

mono–, or *mon*–,	meaning	one or single.
di– or *dis*–,	"	two or twice.
tri– or *tris*–,	"	three or thrice.
tetra–,	"	four.
penta–,	"	five.
hexa–,	"	six.
hepta–,	"	seven.
octo–,	"	eight.
ennea–,	"	nine.
deka–,	"	ten

988.   The numeral prefixes of latin origin are:

un– or *uni*–	= one or single
duo–, or *bi*–, or *bis*–,	= two or twice
ter–, or *tri*,	= three or thrice
quadri–, or *quadra*–	= four
quinque–, or *quinqui*	= five
sexa– or *sexi*–	= six
hepta–,	= seven
octo–	= eight
non–, or *nona*–, or *noni*–	= nine
deca– or *deci*–	= ten

989.   The oxides of chlorine might well be named in the same manner as the oxides of nitrogen, but they are usually named as follows:

*Hypo*chlor*ous* oxide	Cl_2O
Chlor*ous* Oxide	Cl_2O_3
Chlor*ic* Oxide	Cl_2O_5
*Per*chlor*ic* Oxide	Cl_2O_7

These names show the use of two terminal syllables, *–ous* and *–ic*, which are very frequently employed, and nearly always used when only two compounds containing the same elements are to be distinguished from each other.   There are also two prefixes, *hypo*– and *per*–, in the foregoing names of the oxides of chlorine. These and some other prefixes commonly employed in chemical nomenclature will now be explained together with the meaning of the terminations –ic and –ous.

990.   The endings, –ic and –ous, give an adjective form to the nouns to which they are affixed.   Thus the noun *argentum*,

meaning silver, is turned into the adjectives argentic and argentous; the noun ferrum, meaning iron, is transformed into the adjectives ferric and ferrous; the word mercury into mercuric and mercurous; antimony into antimonic and antimonous; arsenic (or arsenum) into arsenic and arsenous; sulphur into sulphuric and sulphurous, etc.

Lexicographically the adjectives argentous and argentic both mean silvern, mercuric and mercurous both mean mercurial, antimonic and antimonous both mean antimonial, arsenous and arsenic mean arsenical, and ferrous and ferric are adjectives which stand for and mean the same as the word iron in the expression iron mortar. But a Latin adjective with the termination –ous differs in degree from one with the ending –ic. Thus argentous means more silvern than argentic; a ferrous compound means one containing a greater proportion of iron than is contained in a ferric compound; mercurous chloride contains relatively more mercury than mercuric chloride does; arsenous oxide contains a greater percentage of arsenic, or, which is the same, a smaller percentage of oxygen, than the arsenic oxide contains; etc.

Therefore, when any two compounds, both consisting of the same two radicals, are to be distinguished by different titles the one containing the greater proportion of the positive radical or lesser proportion of the negative radical is called an –ous compound; and the other, which contains the greater proportion of the negative radical, or the lesser proportion of the positive radical, receives the name of an –ic compound. Of the two chlorides of iron the *higher chloride*, containing proportionately more chlorine, is called ferric chloride, while the *lower chloride*, containing less chlorine in proportion to iron than the other, is ferrous chloride. A *higher oxide* is an –ic oxide, and a *lower oxide* is an –ous oxide.

991. The endings –ic and –ous are sufficient to distinguish two different compounds of the same two radicals, provided there are not more than two such compounds. As there are only two chlorides of iron, it is sufficient to call one the ferr*ous* chloride, and the other the ferr*ic* chloride. But when more than two different compounds are formed by the same two radicals, the terminations –ic and –ous are not only insufficient, but often misapplied, or even confusing.

992. The additional prefixes, other than numerals, which have been employed in chemical nomenclature, are:

Super- and *hyper-*, meaning above, over, in excess.

per-, meaning thorough, to the full extent, through.

sesqui-, half-as-much more, or one and one-half.

sub- and *hypo-*, under or below.

proto-, first or lower.

multi-, or *poly-*, many.

ortho-, straight, regular, normal, original.

meta-, beyond, after, derived from, deviating, altered, different.

pyro-, as produced by fire or high heat.

para-, beside, beyond, different, changed.

Thus, super-oxide means a higher oxide; hyper-manganic acid or per-manganic acid means that acid of manganese which contains the greater proportion of oxygen; per-chloride of iron means the chloride of iron which contains the greatest possible proportion of chlorine with which iron can combine; sesqui-chloride of iron (which is the same as the per-chloride and ferric chloride) means a chloride of iron containing one and one-half times as much chlorine as the lower chloride contains; sub-chloride of mercury is the lower chloride of mercury, or calomel, or mercurous chloride, while per-chloride of mercury is the higher or mercuric chloride; hypochlorous oxide is a lower oxide than the chlorous oxide, and perchloric oxide is a higher oxide of chlorine than the chloric oxide, while chloric oxide is a higher oxide than chlorous oxide; ortho-phosphoric acid means the ordinary phosphoric acid, but meta-phosphoric acid is a different phosphoric acid derived from the ortho phosphoric acid by the subtraction of one molecule of water ($H_3PO_4 - H_2O = HPO_3$), and pyro-phosphates are formed when either meta phosphates or orthophosphates are strongly heated; arabin is the acacia gum, but metarabin is a modified gum formed when acacia is subjected to heat; aldehyde has the formula C_2H_4O, and paraldehyde which has different properties is $(C_2H_4O)_3$, but the difference between them arises from the internal structure.

993. **Nomenclature of Acids.**—Whenever any element forms more than one acid-forming oxide, and accordingly has more than one acid, the different acids are distinguished from each other by names analogous to those given to the respective oxides. Thus, the acid formed by an *–ous* oxide is called an *–ous* acid; the acid formed by an *–ic* oxide is called an *–ic* acid; a *hypo–ous* oxide forms a *hypo–ous* acid, a *per–ic* oxide forms a *per–ic* acid, etc.

Hypochlorous oxide forms hypochlorous acid, chlorous oxide forms chlorous acid, chloric oxide forms chloric acid, perchloric oxide forms perchloric acid, sulphurous oxide forms sulphurous acid, and sulphuric oxide forms sulphuric acid.

994. Nomenclature of Salts.—The salts formed by *–ic* acids are named after the acid by changing the terminal syllable of the adjective to *–ate*, which at the same time converts the adjective into a substantive noun. Thus nitr*ic* acid gives nitr*ates*, sulph*ates* are the salts of sulphur*ic* acid, carbon*ates* are formed by carbon*ic* acid, etc.

Salts formed by *–ous* acids have names ending with *–ite* instead of *–ate*. Thus hypophosphor*ous* acid forms hypophosph*ites*, nitr*ous* acid forms nitr*ites*, sulphur*ous* acid sulph*ites*, and *hypo*chlor*ous* acid *hypo*chlor*ites*.

995. Other characteristic terminal syllables.—The names given to **compound radicals** generally end in *–yl*, as methyl ethyl, butyl, amyl, bismuthyl, nitrosyl, carbonyl, hydroxyl, phenyl, etc.

Names of **alcohols** sometimes end with *–ol*, as in carbinol, phenol, cresol, thymol, etc.; but the same ending is unfortunately also used in the names of other compounds, as in benzol, toluol, etc.

Aldehydes and their derivatives are sometimes given names ending with *–al*, as in chloral.

The terminal *–ane* appears in the names of **hydrocarbons** of the methane series, as in methane, ethane, propane, butane, pentane, hexane, heptane, octane, nonane, decane, etc. In the names of other hydrocarbons and their derivatives the terminal *–ene* is often used, as in benzene, toluene, xylene, naphthalene, anthracene, etc.

In the names of **alkaloids** the ending *–ine* is used, as in strychnine, aconitine, belladonnine, hyoscyamine, emetine, etc. Simple derivatives of ammonia, not containing oxygen, have names ending with the word *amine*, as methyl-amine, ethyl-amine, propyl-amine, phenyl-amine, etc.

Glucosides and other **neutral principles** have names ending with *–in*, as in salicin, populin, aloin, saponin, etc.

Sugars receive technical names ending in *–ose*, as in sucrose or saccharose, glucose, lævulose, maltose, melitose, mannitose, etc. But other carbohydrates also have received similarly constructed names, as, for instance, cellulose, which is not a sugar, but is the matter of which cotton, linen, and the walls of vegetable cells consist.

CHAPTER LVII.

LAWS GOVERNING THE DIRECTION AND COMPLETENESS OF CHEMICAL REACTIONS.

996. The course or direction which a chemical reaction may take is governed by various forces, among which the most important are electro-chemical polarity, and the solubility or non-solubility and state of aggregation of one or more of the products.

997. Malaguti's Law.—In double decompositions between substances in a state of solution "the most energetic acid tends to combine with the most powerful base." We may put this law more comprehensively and correctly in the following form:

All chemical reactions tend to the union of the strongest positive with the strongest negative radical present.

To illustrate its application we will enumerate a few of the most important positive and negative radicals, respectively, in the order of their electro-chemical energy or position, and use the compounds produced by these radicals to show how the law operates.

Positive radicals.		*Negative radicals.*		
Potassium	K	Sulphate radical		SO_4
Sodium	Na	Nitrate	"	NO_3
Calcium	Ca	Chloride	"	Cl
Magnesium	Mg	Bromide	"	Br
Iron	Fe	Iodide	"	I
Copper	Cu	Tartrate	"	$C_4H_4O_6$
Mercury	Hg	Acetate	"	$C_2H_3O_2$
Hydrogen	H	Carbonate	"	CO_3

In the preceding table potassium is the most powerful of all the *positive radicals* enumerated, then sodium, next calcium, etc., down to hydrogen, which is a weaker electro-positive radical than any of the others. Of the *negative radicals* the sulphate radical is the strongest, and of the others included in this table,

the nitrate radical stands next to the sulphate radical, the chlorine, bromine, iodine, etc., down to the carbonate radical, which is the weakest of them all.

Now, according to Malaguti's law, sulphuric acid (which is hydrogen sulphate, H_2SO_4) must decompose all nitrates, chlorides, bromides, iodides, tartrates, acetates, and carbonates. Nitric acid (which is hydrogen nitrate, HNO_3) must decompose all chlorides, bromides, iodides, tartrates, acetates, and carbonates. Hydrochloric acid (which is hydrogen chloride, HCl) must decompose all bromides, iodides, tartrates, acetates and carbonates, etc. Potassium must displace sodium, calcium, magnesium, iron, copper, mercury and hydrogen from their compounds. Iron must take the place of copper, and copper in turn can usurp the place of mercury.

Potassium being a stronger positive radical than copper, and the acetate radical being a weaker negative radical than the nitrate radical, if we mix a solution of potassium acetate with a solution of copper nitrate, there must be a reaction, resulting in the formation of potassium nitrate and copper acetate, for the reaction tends to the union of the strongest positive radical (potassium) with the strongest negative radical (the nitrate radical).

In the same way and for the same reason we would get the following reactions:

$$2KNO_3 + MgSO_4 = K_2SO_4 + Mg(NO_3)_2$$
$$6KC_2H_3O_2 + Fe_2Cl_6 = 6KCl + Fe_2(C_2H_3O_2)_6$$
$$Ca(C_2H_3O_2)_2 + MgBr_2 = CaBr_2 + Mg(C_2H_3O_2)_2$$
$$2KBr + FeSO_4 = K_2SO_4 + FeBr_2$$
$$Mg(C_2H_3O_2)_2 + Pb(NO_3)_2 = Pb(C_2H_3O_2)_2 + Mg(NO_3)_2$$
$$Na_2CO_3 + 2HCl = 2NaCl + CO_2 + H_2O$$
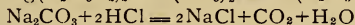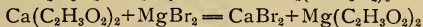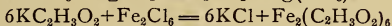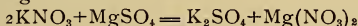
Malaguti's law, as stated and illustrated above, holds good at ordinary temperatures if the products of the reaction are both soluble salts; but the reactions are not complete (998).

998. Berthollet's investigations prove that the operation of Malaguti's law (997) is greatly modified by the relative masses of the factors of the reaction, and by the relative solubilities

of the possible products, and it has been observed that a reaction in accordance with Malaguti's law is never quite complete unless one of the products of the reaction is either a volatile or an insoluble compound (999). Thus, while, in obedience to Malaguti's law, a solution of potassium chloride mixed with a solution of copper sulphate should produce potassium sulphate and copper chloride—

$$CuSO_4 + 2KCl = K_2SO_4 + CuCl_2$$

the resulting liquid will in reality contain all of the four salts named; a mixture made of sulphuric acid with a solution of sodium nitrate will contain sodium sulphate, sodium nitrate, sulphuric acid, and nitric acid; and a mixture made of a solution of magnesium sulphate with a solution of potassium tartrate will contain potassium sulphate, magnesium sulphate, potassium tartrate and magnesium tartrate.

These are the results obtained when the proportions of the compounds mixed are the proportions required by theory for complete double decomposition according to the equations representing the reactions which should ensue according to Malaguti's law.

But although the reactions which take place in accordance with this law do not progress to completion, the *tendency* of the reaction is unmistakable, and it is simply obstructed by physical conditions.

Reactions, incomplete though they be, may thus take place between salts in a state of solution without any outward sign if the factors and products of the reaction are colorless as well as soluble.

999. **Berthollet's Law of the Formation of Insoluble Compounds.**—*If any two of the radicals taking part in a chemical reaction between salts in solution would produce an insoluble compound if united to each other, then these radicals will unite.*

In other words, " when we cause two salts to react by means of a solvent, if, in the course of double decomposition, a new salt can be produced which is less soluble than those we have mixed, then that new and less soluble salt will be formed."

Or, *whenever, in any double decomposition between compounds in solution, an insoluble product is possible, then that insoluble product will inevitably be formed.*

This law is general in its operation ; it produces complete reactions in the direction which it indicates, and it nullifies Malaguti's law in all cases where the two laws are in opposition to each other.

A knowledge of the relative solubilities of chemical compounds, therefore, enables us to predict with certainty the direction of the reaction in all cases where the factors of the reaction furnish the radicals required for the formation of insoluble products, and it also enables us to devise methods for the preparation of numerous substances.

Knowing that lead iodide is insoluble, we also know that it must be formed whenever a solution of any soluble lead salt is mixed with the solution of any soluble iodide. Knowing that lead iodide is a yellow insoluble solid, we know that we can not mix a solution of lead acetate or lead nitrate with a solution of potassium iodide, sodium iodide, or of the iodide of either ammonium, calcium, magnesium, zinc, or iron, without getting a yellow precipitate.

A solution of any one of the soluble salts of any of the heavy metals can not be mixed with a solution of any soluble hydrate, or carbonate, or phosphate, without producing a precipitate, for, as we know, the hydrates, carbonates and phosphates of the heavy metals are all insoluble. Salicylate of quinine being insoluble in water we know that it would be impossible to mix an aqueous solution of hydrochlorate of quinine with a solution of sodium salicylate without getting a precipitate of quinine salicylate; but if enough alcohol is present, in which the quinine salicylate is soluble, no precipitate of that compound will be obtained, although quinine salicylate is of course formed in accordance with Malaguti's law, but we might expect instead (if enough alcohol is present) a precipitate of sodium chloride, which, although soluble in water, is not soluble in a liquid containing a considerable amount of alcohol.

Most of the chemical incompatibilities met with in making extemporaneous liquid preparations arise from the formation of insoluble compounds. Hence the great importance of knowing the relative solubilities of chemicals.

Common water, containing carbonates, chlorides, and sulphates, will not make clear solutions of the water-soluble salts of silver, lead, mercury, etc., because the carbonates, chlorides or sulphates of these and some other metals and bases are insoluble.

1000. Berthollet's law of the formation of volatile products.—When dry heat is applied to a mixture of two compounds, if any volatile product can be formed by double decomposition, then that volatile product will be formed.

Thus when ammonium chloride and calcium oxide are heated together, the products calcium chloride, ammonia and water are formed; when a mixture of mercuric sulphate and sodium chloride is heated, mercuric chloride sublimes and sodium sulphate remains.

It may be said in addition that compounds which may be split up into two or more other compounds, of which one is volatile, are comparatively unstable and may be decomposed either by heat alone, or by double decomposition aided by heat, or even by double decomposition without the aid of heat. In other words, simple decomposition or double decomposition takes place, as a rule, more readily when one or more of the products of the reaction are volatile than when no volatile products are formed.

Thus carbonates are comparatively unstable; they are easily decomposed by even weak acids, and are split up by high heat.

The student should here refer again to the action of heat upon salts (538).

1001. Whenever a chemical reaction ensues in accordance with the law of Malaguti (997), it progresses to completion provided one of the two products is gaseous, as in the decomposition of carbonates, sulphites, etc., by stronger acids.

1002. It will now be readily understood by the student that the synthetical and analytical reactions applied in the production of chemical compounds and in analytical work are based chiefly upon the laws of Malaguti and Berthollet which have just been presented and to which indirect reference has been made also in the preceding pages.

CHAPTER LVIII.

OXIDATION AND REDUCTION.

1003. **Oxidation.**—To induce any metal or other element, or any compound, to take up or unite with oxygen is to oxidize that element or compound.

Zinc oxide may be made by heating the metal strongly in free access of air. **Combustion** in oxygen or air, whether slow or rapid, is oxidation. To cause a lower oxide to take up more oxygen so as to form a higher oxide and to convert an -*ous* acid into an -*ic* acid, or an -ous salt into an -ic salt must also be called oxidation. Thus when an arsenite is converted into an arsenate, a sulphite into a sulphate, or phosphorous acid into phosphoric acid, or nitrogen dioxide into nitrogen tetroxide, oxidation takes place.

1004. But the direct union of oxygen with an element, or the addition of oxygen to any compound, or the introduction of oxygen into a molecule, is not the only methods of oxidation possible.

The proportion of oxygen in a molecule may be indirectly increased by removing some other element. When alcohol, C_2H_5OH, is changed to aldehyde, C_2H_4O, this change is really effected by oxidation because two atoms of the hydrogen of the alcohol are oxidized to water and thereby removed from the C_2H_5OH, leaving C_2H_4O, which at the same time contains a greater proportion of oxygen than is contained in the alcohol, for alcohol contains 16 parts of oxygen in 30, while the aldehyde contains 16 parts in 28.

1005. When the ferrous sulphate is converted into ferric sulphate by means of nitric acid, it is the hydrogen of the sulphuric and nitric acids used that is oxidized to water at the expense of the nitrate radical, thus:

$$6FeSO_4+3H_2SO_4+2HNO_3 = 3Fe_2(SO_4)_3+N_2O_2+4H_2O,$$
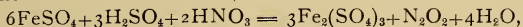
and when ferrous chloride is converted into ferric chloride with hydrochloric and nitric acids the hydrogen of the acids is oxidized to water, while the chlorine from the hydrochloric acid raises the ferrous chloride to ferric:

$$6FeCl_2+6HCl+2HNO_3 = 3Fe_2Cl_6+N_2O_2+4H_2O.$$

Both reactions are instances of *oxidation.*

The following reaction is also an example of oxidation:

$$As_2O_3+2NaNO_3+Na_2CO_3 = Na_4As_2O_7+N_2O_3+CO_2.$$
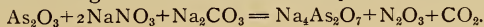
Nitric acid is also decomposed by organic substances, the molecule of nitric acid being split up into the two radicals, NO_2 and HO, of which it is composed, and the group NO_2 is thus made to enter into the organic molecule, where it replaces one atom of hydrogen, this hydrogen uniting with the hydroxyl to form water, as when cotton is converted into gun-cotton:

$$C_{12}H_{20}O_{10}+6HNO_3 = C_{12}H_{14}O_4(O.NO_2)_6+6H_2O.$$
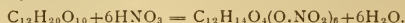
1006. The **oxidizing agents** are either oxygen itself or some oxygen compound which readily gives up all or a portion of its oxygen, such as nitric acid and other nitrates, chromic anhydride, potassium permanganate, potassium chlorate, manganese dioxide, etc.

1007. Chlorine and the other halogens may act as indirect oxidizing agents in organic chemistry by removing hydrogen from the organic compounds; or, still more indirectly, by first introducing chlorine in the place of the hydrogen of the molecule, and subsequent introduction of hydroxyl to take the place of the chlorine, which can be effected with some metallic hydrate.

1008. **Reduction** is the opposite of oxidation. It is the removal of oxygen from a molecule, or the diminution of its proportion by the introduction of other elements into the same molecule, or the replacement of a portion or all of the oxygen by some other radical.

The reduction of oxides to metals is sometimes easily accomplished by heat alone, as in the case of the oxides of silver, mercury and gold.

1009. **Reducing Agents** are substances having a strong affinity for oxygen, either at ordinary temperatures or when strongly heated with the oxygen compound. Carbon and hydrogen are often employed as reducing agents.

Thus, iron ore is reduced to metallic iron by smelting it down in a furnace with charcoal, and "reduced iron" of the Pharmacopœia is made by passing a current of hydrogen over oxide of iron heated to redness.

Sulphurous acid and other sulphites are also sometimes used as effective reducing agents.

Less effective reducing agents are glycerin, alcohol, sugar, tannin, and many other organic substances.

CHAPTER LIX.

NEUTRALIZATION.

1010. Soluble normal salts are most frequently prepared by neutralizing the proper acids by the proper bases, or by metals, oxides, or carbonates. Thus any soluble sulphate may be produced by neutralizing sulphuric acid, any acetate by neutralizing acetic acid, etc., by the requisite metal, oxide, base or carbonate.

1011. Test papers.—Litmus is a blue coloring matter made from certain lichens. Acids turn it red. Alkalies restore the blue color.

When suitable unsized paper, like thin, white filter paper, is dipped in a weak solution of litmus and then dried it forms what is called "test paper." The solution of litmus used for this purpose is made with weak alcohol, and when used without the addition of acid it forms *blue litmus paper*, which is turned red by acids, by certain acid salts, and by some normal salts in which the acid radical is a powerful one while the positive radical is comparatively weak. If the litmus tincture is treated with a little diluted hydrochloric acid so that its blue color is just changed to red, then paper dipped in this liquid and dried constitutes *red litmus paper*, which is turned blue by soluble bases and by some salts of strong bases with weak acids.

The litmus solution or tincture may be made of one ounce powdered litmus to ten fluidounces diluted alcohol; macerate for a day, shaking occasionally, and then filter.

1012. Whenever it is stated in the Parmacopœia or in any other book that any certain substance has " an acid reaction on test paper," or that it exhibits *an acid reaction,* the statement means that the substance turns blue litmus red; whenever a substance is said to give *an alkaline reaction,* this means that it turns red litmus blue; and when a liquid or substance has *a neutral reaction* it does not change either the blue or the red litmus paper.

Remember that acids turn blue litmus red, that alkalies turn red litmus blue, and that neutral salts do not effect litmus paper at all.

Certain other blue vegetable colors are affected by acids and alkalies in precisely the same way as litmus.

1013. When a strong acid and a strong base neutralize each other the normal salt formed has a neutral reaction on test paper.

Thus, if you put 200 grains of diluted acetic acid in a beaker, or in a graduate, and then add ammonia water, a little at a time, until the liquid no longer turns blue litmus paper red, but not so long that the liquid will turn red litmus blue—in other words, until the reaction is neutral— you will find that you have used just 34 grains of water of ammonia ; the diluted acetic acid turns blue litmus paper red, and the ammonia water turns red litmus paper blue ; but if you mix exactly 200 grains of strictly pharma-copœial diluted acetic acid with exactly 34 grains of water of ammonia of precisely the strength prescribed by the Pharmacopœia, you will find that the resulting liquid has a neutral reaction. If, however, the acetic acid is too weak the reaction will be alkaline, and if the ammonia is too weak the reaction will be acid.

In making the solution of acetate of ammonium according to the Phar-macopœia, diluted acetic acid is *neutralized* with ammonium carbonate; that is, carbonate of ammonium is added, a little at a time, t› the diluted acetic acid until the reaction of the solution is neutral to test paper, or litmus paper.

1014. In testing liquids with litmus paper to ascertain their reaction, it is necessary that the coloring matter of the paper (the litmus) be soluble in or wetted by the liquid, for otherwise the color is not affected. Thus, to test strong ether, for instance, it is necessary to moisten the litmus paper with water before applying the ether to it. In testing solutions obtained by neu-tralizing acids with carbonates, it may be the case that the solution is charged with carbon dioxide ("carbonic acid") and will, therefore, give an acid reac-tion on test paper, even if the acid has been neutralized by the carbonate; if the liquid be heated sufficiently to expel the "carbonic acid gas," or car-bon dioxide, the reaction obtained will, however, be true and may be found to be neutral notwithstanding the fact that it was acid before the liquid was heated.

1015. Some salts are always alkaline in reaction, although they are normal salts, and even salts of an acid constitution— that is, salts still containing replaceable positive hydrogen— may have a decidedly alkaline reaction, as, for instance, potas-sium bicarbonate (acid carbonate of potassium), which at once turns red litmus paper blue. But this is because the carbonate radical is a very weak negative radical, while potassium is the strongest positive radical.

Several normal salts of iron, zinc, etc., with the stronger acids, have an acid reaction, and even the basic ferric sulphate gives an acid reaction. This is because the sulphate radical is a

very powerful negative radical, while the iron is not sufficiently strongly positive to neutralize it as to its effect on vegetable colors.

It is, therefore, to be always borne in mind that a normal salt, which is often called a *neutral salt*, does not mean a salt with a neutral reaction on test paper, and that a salt having such a reaction is not necessarily a normal or neutral salt chemically. In other words neutrality to test paper and neutrality as to chemical structure or composition are two wholly different things.

1016. Soluble salts can not advantageously be prepared by double decomposition except when the bye-product is insoluble, so that the reaction is complete. But they can be made from acids by neutralization or saturation.

Sulphate of zinc can be made by dissolving zinc in diluted sulphuric acid. All that is necessary in this case is to add enough zinc—a little more than the acid can dissolve—and to let the acid act upon the metal until it will not dissolve any more of it. The zinc will continue to dissolve just as long as there is any acid left ; but when all the acid has been *saturated*, or turned into zinc sulphate, no more zinc can be dissolved, for zinc is insoluble in a solution of its own sulphate. Similar results are obtained in many other cases when metals are dissolved in acids ; but not in all, for sometimes basic salts are formed if the metal is used in excess.

If, instead of zinc, we should add the oxide of zinc, or zinc hydrate, or zinc carbonate, to the diluted sulphuric acid, the final result would be the same—zinc sulphate is obtained in either case.

If the proportions of acid and metal, oxide, hydrate, or carbonate are exactly those required by theory, according to the chemical reaction, a normal salt will generally be obtained; or, if the metal, oxide, hydrate or carbonate is insoluble in a solution of the normal salt formed with the acid used, an excess of either of them may be added to the acid with the assurance that a normal salt is formed, and the bye-products in these reactions are either gases which pass off or water which is unobjectionable. When one of the products of a reaction is either a gas or water the reaction also progresses to completion. When carbonates are dissolved in acids the gas CO_2 together with water are the bye-products (1026).

1017. The proportions required by theory to an even neutralization or double decomposition are shown by the chemical equations which represent the reactions:

$$Zn + H_2SO_4 = ZnSO_4 + H_2$$
$$65 \quad\quad 98 \qu\quad\quad 161 \qu\quad\quad 2$$
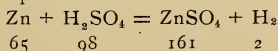
Thus it requires 65 pounds of zinc and 98 pounds of sulphuric acid to make 161 pounds of zinc sulphate, and 2 pounds of hydrogen will be formed at the same time. As the hydrogen is a light gas insoluble in solution of sulphate of zinc, it easily passes off. But these proportions are theoretically right only in case the sulphuric acid is *absolute* (or *all* sulphuric acid, H_2SO_4, or 100 per cent. strength), which it never is. The sulphuric acid of the pharmacopœia and of the market is generally of from 96 to 98 per cent. strength, or contains from 96 to 98 per cent. H_2SO_4. If it should contain 98 per cent., then of course 100 pounds of it would be required for 65 pounds of zinc, for 100 pounds of a sulphuric acid of 98 per cent. strength would of course be equal to 98 pounds of H_2SO_4. On the other hand, as the zinc ought to be used in excess, 98 pounds of ordinary sulphuric acid is sufficient for 65 pounds of zinc, and 100 pounds of ordinary sulphuric acid (equal to 98 pounds of H_2SO_4) would require a little more than 65 pounds of zinc. Again—

$$Zn + 2HCl = ZnCl_2 + H_2$$
$$65 \quad\quad 73 \quad\quad 136 \quad\quad 2$$
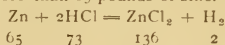
This reaction indicates that 73 pounds of HCl must be used for 65 pounds of zinc to make 136 pounds of $ZnCl_2$. It is, of course, 73 pounds of absolute HCl and not 73 pounds of the hydrochloric acid as we find it in the market; the hydrochloric acid used contains only 31.9 per cent. of HCl, so that in order to get 73 pounds of HCl we must take 229 pounds of the ordinary acid.

CHAPTER LX.

PRECIPITATION.

1018. Precipitation is the formation of insoluble solids in liquids.

Precipitation can occur only in liquids, and the *precipitate* is always solid.

Precipitation results when the dissolved matter is converted into insoluble matter, or when the solvent is changed so as to become a non-solvent.

When the dissolved matter is changed that change is the result of chemical reaction.

When the liquid in which the precipitation is caused to take

place becomes changed from a solvent to a non-solvent while the previously dissolved matter remains the same in kind, this change in the liquid is generally produced by the addition of a non-solvent miscible with the first liquid.

Thus resins, camphor and other alcohol-soluble substances insoluble in water are precipitated from their alcoholic solutions on the addition of water, and gums, albumin, and other water-soluble substances insoluble in alcohol are precipitated from their water solutions by the addition of alcohol.

1019. Precipitation resulting from a change in the liquid, by which it is rendered incapable of holding the dissolved matter any longer in solution, is sometimes called "physical precipitation" because it is a purely physical phenomenon unaccompanied by any chemical change. The formation of new and insoluble solids in a liquid by chemical reactions is called "chemical precipitation."

1020. The separation of solid matter from a solution by a reduction of temperature, or by loss of a portion of the solvent from evaporation, is not usually precipitation, but crystallization.

Nor is the separation of a liquid from its solution upon the addition of a non-solvent called precipitation, as for instance the separation of castor oil from its solution in alcohol by the addition of water.

1021. Precipitation frequently takes place as the result of slow chemical reactions caused by the influence of changes of temperature, the action of light or of air, and other natural causes. But by far the most frequent cause of precipitation is the intentional mixing of two or more substances, generally in the form of solution for the purpose of producing certain products or for analytical purposes, and these intentional precipitations are the result of double chemical decomposition attended by the formation of insoluble products.

1022. A great number of chemical compounds are insoluble in water, and these compounds can, therefore, usually be prepared by double decomposition.

Moreover, the value of many of the most important analytical reagents depends upon precipitations caused by them.

Precipitation is accordingly of very great importance in chemistry and pharmacy.

But this chapter will be devoted wholly to the consideration of precipitation as a synthetical process.

1023. For the preparation of insoluble pharmaceutical chem-
icals precipitation by double decomposition is found to be a
more advantageous method in a great majority of instances
than any other.

1024. To produce precipitation by double decomposition
there must be two factors of the reaction. One of these is called
the *precipitand* and the other is the *precipitant*.

The precipitand is *always a liquid*.

The vessel in which precipitation is to be performed is called
the *precipitating vessel*. It may be a beaker, a wide-mouthed
bottle, a stone jar, a barrel, or any other suitable vessel, according
to the quantities operated upon and the nature of the materials.

The **precipitand** *is the liquid first put in the precipitating vessel:*
and the **precipitant** is the other factor of the reaction which
must be added to the precipitant.

It is obvious from the preceding statements that you can make either
of the two substances used the precipitand or the precipitant at will. Which-
ever solution you place in the precipitating vessel *first* is by reason of that
fact alone the precipitand, and the other must consequently be the precipitant
and must be added to the precipitand. But we shall soon see that it makes a
vital difference which of the two substances is used as a precipitand.

The precipitant may be either a liquid, a solid, or a gas.

1025. The best results are obtained when both the pre-
cipitand and the precipitant are liquids. They are generally
solutions of salts. Solutions which are to be used for the prep-
aration of chemical products by precipitation must be perfectly
clear; they are invariably to be filtered through good white filter
paper, unless so corrosive as to disintegrate the paper; or, if
they can not be filtered through paper, they must be allowed to
stand long enough to become clear by the subsidence of any
solid particles in them, or by filtration through asbestos or glass
wool, or in some other effective manner.

1026. When two solutions constitute the precipitand and
precipitant, as is very generally the case, they must be mixed
with each other in just the order and manner required by the
circumstances of each case and the course of the ensuing reac-
tion. When they have been properly mixed and the double

decomposition completed, there are usually two products of the reaction contained in the precipitating vessel. One of these is the precipitate or insoluble solid, which is usually the *principal product*, and the other is the soluble matter held in solution in the liquid.

The liquid in which the precipitate is formed is sometimes called the *mother liquor*, which term is also used to designate the liquid remaining after the deposition of crystals from a solution. The matter held in solution in the mother liquor is usually the *secondary product*, or *bye-product*. It sometimes happens, however, that the soluble product is the principal product, and the precipitate a bye-product.

When the precipitate is heavy enough to descend to the bottom of the vessel, leaving the greater part of the liquid standing over it and free from solid particles, then the mother liquor is frequently referred to as *the supernatant liquid*.

1027. Proportions of the Factors of Reaction.—The relative quantities of the two factors of the reaction necessary to complete mutual decomposition are, of course, easily calculated from the molecular weights in accordance with the chemical equation representing the reaction.

Thus, if we want to make mercuric iodide we must have a soluble mercuric compound and a soluble iodide as our materials; we select mercuric chloride and potassium iodide as the most convenient and suitable. The reaction between them would be :

$$HgCl_2 + 2KI = HgI_2 + 2KCl.$$
$$271 \quad 2\times166 \quad 454 \quad 2\times74.6.$$

The molecular weight of mercuric chloride is 271; of potassium iodide, 166 ; but two molecules of potassium iodide are necessary, as seen by the equation, so that 2×166 or 332 parts of it must be taken for 271 parts of mercuric chloride; these materials will give as products 454 parts of mercuric iodide, and 2×74.6 or 149 parts of potassium chloride. To prove the correctness of these quantities add together the numbers on each side :

271		454
	and	
332		149
603		603

The sums are equal and, therefore, correct if the reaction is correctly rep-
resented by the equation, as in this case it is, for you will find by the valences
of the four radicals Hg, K, I and Cl, and the fact that the same four elemen-
tal radicals, and the same number of atoms of each of them, are to be found
on both sides.

1028. It is evident that if exactly 271 ounces of mercuric chloride and
332 ounces of potassium iodide are used, and if the reaction between them
is complete, so that every grain of each is decomposed, then we would get
exactly 454 ounces of mercuric iodide and 149 ounces of potassium chloride.

In some cases the exact proportions required by theory (according to
the equation representing the reaction) are the proper proportions; but in by
far the greater number of cases of double decomposition it is absolutely
necessary to vary these proportions and to use an excess of the precipitand
(1024).

The theoretical proportions will not do when it is necessary to insure
complete decomposition of at least one of the factors of the reaction—the pre-
cipitant; and this is generally necessary to insure a pure product.

1029. As a rule that factor of the reaction which supplies
the positive radical of the product must be completely decom-
posed and must be used as the precipitant ; while the other
factor, which furnishes the negative radical of the product must
accordingly be used in excess of the amount required by theory,
and must be the precipitand. In such a case, at the end of the
reaction, all of the precipitant is completely decomposed, while
a small quantity of the precipitand remains in the mother liquor
together with the bye-product(1026).

Any considerable deviation from the proportions required by
theory would, however, involve unnecessary loss or waste, so
that the *excess* used of the precipitand is to be moderate.

In the production of mercuric iodide from mercuric chloride and potassium
iodide (1027) the potassium iodide must be used in excess, and its solution
must therefore be put in the precipitating jar first, because the mercuric
chloride which furnishes the positive radical (Hg) of the product (HgI_2) must
be completely decomposed.

1030. The Solutions employed in making chemical prod-
ucts by precipitation must be of suitable degree of strength and
temperature; and they must be mixed in the proper order, grad-
ually and with brisk stirring.

Dilute and cold solutions generally tend to produce finely divided, light and bulky precipitates, while strong and hot solutions, as a rule, produce coarser and heavier precipitates.

1031. Physical character of the precipitate.—This depends upon several conditions. Aside from the fact that each particular substance has a tendency toward a given form or physical condition, it is generally the case that this condition may be more or less modified by external influences, as has been indicated with regard to the degree of strength and temperature of the solutions (1030). Instant precipitation usually results in a finely divided product, while a precipitate slowly formed may be coarser.

When hot solutions are employed and the substance precipitated is not insoluble in hot water the precipitate will be distinctly crystalline, whereas the same substance can be obtained in very fine powder when precipitated from cold liquids.

Precipitates vary, then, in density, state of division, and form according to their chemical composition, and the conditions under which they were formed.

They may be light or heavy, fine or coarse, amorphous or crystalline, gelatinous or curdy, pulverulent or stringy, etc.

1032. The precipitate is frequently materially affected by continued contact with the mother liquor. Experience has demonstrated that in some cases it is necessary to allow the precipitate to remain in the liquid for a time before it is washed, while in other cases it is necessary to remove it from the liquor as soon as possible. The method of procedure must, therefore, be determined in each case according to the requirements.

1033. As the precipitate is in contact with the second product in the liquid, it is not sufficient to simply collect and dry it, but it must be *washed* first.

The washing and collection of precipitates in synthetical pharmaceutical processes may be accomplished in various ways.

If the precipitate is heavy so as to sink to the bottom of the precipitating vessel, the washing may be effected by *affusion and*

decantation of water. After the precipitate has been formed and allowed to subside, the mother liquor may be *decanted*, or poured off, or it may be removed by means of a siphon. Then the pre- cipitating vessel is filled up with pure water, and the precipi- tate stirred up well with this water, after which subsidence is allowed to take place again, and as soon as the precipitate and the supernatant liquid, which now consists of *wash water* or *washings*, have separated, the wash water is immediately again decanted and the vessel filled up with pure water. This alter- nate affusion and decantation of water is repeated several times, being continued until the washings no longer contain any solu- ble matter, which may be detected by the taste as long as the amount is considerable and by chemical tests when less.

When the precipitate is very light and large quantities oper- ated upon, the washing may be effected by mixing the *magma* (a finely divided, bulky, light precipitate which does not readily separate from the liquid is called a "magma") with water in a suitable vessel, and then pouring the mixture upon a muslin strainer, so that the wash water may run off; then returning the magma to the vessel again to be mixed with a fresh portion of pure water and pouring the mixture again upon the strainer as before, repeating this as many times as may be necessary.

Very small quantities of precipitates are best washed on a paper filter, the wash water being in this case poured over the precipitate in the filter and allowed to run through, after which more water is added, and the washing thus continued until the precipitate is freed from the soluble matter.

The washing is sometimes effected with hot water, and in some cases with alcohol or other liquids, but water of common temperature is in most cases employed for this purpose.

1034. When the washing is completed, the wet precipitate is put on a paper filter or a muslin strainer, according to quan- tity, and allowed to stand until drained free from the end wash- ings as far as practicable, after which the moist product is spread out on paper or muslin to dry.

Sometimes the precipitate retains the water so tenaciously

that it is necessary to expedite the work by forcibly pressing the water out. The magma or other precipitate is for this purpose put in a press cloth or press bag and the water squeezed out of it by means of a screw press.

In drying precipitates it is necessary to bear in mind that many substances are decomposed or altered by contact with the air or by the influence of light, and such precipitates as are liable to be injured in this way must be protected as far as possible.

Sometimes the drying process may be hastened by the aid of heat; but in many cases the product is damaged by heat.

1035. When the precipitate has been dried (it must be made perfectly dry) it is powdered and sifted through a fine sieve, unless already in uniformly fine powder.

PART III.

ABOUT DRUGS.

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CHAPTER LXI.

INTRODUCTORY.

1036. Medicines.—All substances used to relieve or remove pain or disease are called medicines. They include crude drugs, medicinal chemicals, and pharmaceutical preparations.

1037. Crude Drugs are medicines consisting of natural or unprepared products derived from the mineral, vegetable and animal kingdoms, such as minerals, plants or parts of plants, exudations like gums, resins and oleoresins, and animals or animal substances like cantharides, castor, musk, etc.

Many substances not in their natural state, but more or less prepared, are, however, also called crude drugs when common articles of commerce aside from their pharmaceutical and medicinal uses, or articles not prepared by pharmacists or chemists, as oils, etc.

1038. Inorganic Drugs are those derived from the mineral kingdom, either in the natural state, or such as have passed through some process of manufacture or purification, but not yet in a condition suitable for medicinal applications: For Ex.— Native sulphide of antimony, lime, impure sulphates of iron, zinc, magnesium and copper, sugar of lead, litharge, common potash, borax, alum, soda, sulphur, commercial acids, etc.

1039. Organic Drugs are crude drugs derived from the

vegetable and animal worlds. The plant drugs are numerous, animal drugs few.

1040. Vegetable Drugs are the most important of all drugs.

There are thousands of plants which have been at one time or another used for medicinal purposes, and of these about six to eight hundred are still used sufficiently to be articles of commerce.

In the Pharmacopœias of the United States, Great Britain, Germany, France and Sweden there are very nearly 600 vegetable drugs, of which about 100 are official in all five, less than 60 in four only, a little over 40 in three only, and less than 100 in two pharmacopœias only. But one-fifth of these drugs are not active medicinal substances being used only pharmaceutically in preparations employed as vehicles for other and more active medicinal substances, or as flavoring agents, etc.

1041. Plant drugs sometimes consist of the entire plant; sometimes of several of its organs; but generally of only one plant part, as the root, leaf, seed, bark, flowers, etc. Other vegetable drugs consist of starches, crude gums, resins, gum-resins, oleoresins, fixed oils, volatile oils, etc.

1042. Animal Drugs were at one time more common than now. At present the only drugs of animal origin contained in the Pharmacopœia of the United States are : Suet, wax, spermaceti, lard, lard oil, cod liver oil, pepsin, ox-gall, castor, musk, cantharides, cochineal, isinglass, and yolk of egg.

1043. Chemicals are substances of definite chemical composition, such as oxides, hydrates, acids, salts, chlorides, bromides, iodides, etc., prepared by chemical manufacturers or pharmaceutical chemists.

The chemicals are, of course, grouped into two classes : inorganic chemicals derived from materials belonging to the mineral kingdom, and organic chemicals derived from plants or animals, or from hydrocarbons.

1044. Pharmaceutical Chemistry is the chemistry of pharmacy. It includes not only the study of chemistry, in its

relations to the preparation, identification and examination of medicinal *chemicals*, both inorganic and organic, but also the study of the chemical constituents of the *crude drugs,* and the chemistry of " dispensing."

1045. Pharmaceutical Preparations are medicines prepared in convenient forms for direct administration or application, such as solutions, powders, pills, mixtures, syrups, tinctures, extracts, liniments, ointments, plasters, gargles, injections, suppositories, etc.

1046. Galenical Preparations are pharmaceutical preparations prepared by methods which do not include any chemical reactions or changes.

When the constituents of the preparation are simply mixed, or when the active principles of a drug are extracted by means of simple solvents, the product is a Galenical preparation and the method of preparing it is a Galenical process.

It is named so after Galen, a celebrated physician who lived in the second century and whose teachings were of the highest authority for about thirteen or fourteen centuries. Galen's medicines were, of course, limited to teas, decoctions, tinctures, vinegars, electuaries, and other preparations in no way dependent upon a knowledge of chemistry, a science which was unknown in Galen's time.

When chemistry at last became an inportant power in the hands of the pharmacist there were warm controversies between the adherents of Galen and the disciples of Paracelsus, Valentine, and others who introduced chemicals into the Materia Medica.

1047. Materia Medica is the Latin for *medicinal substances*, and as commonly used the term is synonomous with pharmacology. In its more appropriate application *materia medica* means simply the materials from which medicines are prepared. In this sense the term has been used in pharmacopœias and other books ; thus the medicines were divided into two classes, one class comprising the " materia medica list," and the other the " preparations."

1048. For the purpose of classifying medicines by placing the crude drugs, or raw materials, in one group and the preparations to be made from them into another, the expressions *pharmaca simplicia*, "simple medicines," and *pharmaca præparanda*, "medicines to be prepared," have also been used.

1049. But a considerable number of pharmaceutical substances or materials have no medicinal action, being used simply as diluents, solvents, vehicles, bases, excipients, flavoring or sweetening ingredients, etc. For the sake of convenience these are treated as if they were drugs, and the general term **Materia Pharmaceutica** is used to designate all substances used in the preparation of medicines whether these substances be medicinally active or inert.

Among the materia pharmaceutica not possessing medicinal activity are water, sugar, starch, lard, wax, glycerin, tragacanth, etc.

1050. Pharmacology (from φάρμακον, "medicine," and λόγος, "discourse") is that branch of the study of medicine which treats of the *Materia Medica*, and of the sources, commercial history, preparations, effects, uses and doses of medicinal substances.

It enumerates the individual preparations or forms of administration used or useful, but does not treat of the general principles, processes and manipulations of pharmacy.

1051. Pharmacognosy (from φάρμακον, "medicine," and γνῶσις, "knowledge") is that branch of the study of medicines which treats of the natural origin, appearance, structure and other means of identification of organic drugs.

The study of pharmacognosy necessarily demands a fair knowledge of the organs, tissues, and microscopical structure of plants, and also a sufficient general knowledge of systematic botany.

Botanical drugs are sometimes so nearly alike that it is necessary to resort to the microscope to remove doubt.

1052. Identification of Medicinal Substances.—The ability to identify or recognize individual drugs, chemicals and

pharmaceutical preparations is extremely valuable, since it is the means of detecting and preventing mistakes. Many of these substances may easily be recognized with the aid of the physical senses—sight, smell and taste. Familiarity with the more important drugs, chemicals and pharmaceuticals that possess striking physical characteristics should, therefore, be cultivated. Crude drugs, especially, may often and with certainty be recognized by the form, color, odor and taste. In other cases we may not be able to positively identify a drug by these physical properties, and yet when a mistake has been made we may detect it by our ability to at least see that the article before us is *not* what it *should* be. But, although the external appearance and other physical properties of medicines should be familiar to us, and are the most valuable aids in detecting or avoiding errors, yet we must also make use of such other aids as we can render available for this purpose.

A good knowledge of plant structure and plant organs, and ability to use the microscope, are necessary to proficiency in pharmacognosy. A knowledge of chemistry is requisite to identify chemical substances by appropriate qualitative tests ; and chemistry frequently aids us in identifying even Galenical preparations which are the most difficult of medicines to identify.

Notwithstanding the difficulties, every good pharmacist should be able to identify such common preparations as the tinctures of opium, rhubarb, aloes or arnica; he should immediately recognize the odors of jalap, ipecac, aloes or any other drugs which are equally characteristic in this respect.

1053. **Varieties of Drugs.**—Of many crude drugs there are several varieties. Thus we have several varieties of ginger, cinnamon, sarsaparilla, catechu, cinchona, senna, etc. It is important that in each such case the particular variety or varieties intended should be plainly specified or described. Whenever any two varieties of the same drug differ greatly from each other they are in fact to be distinguished from each other as if they were different drugs, which, in effect, they really are.

1054. Grades.—Each drug should be in good condition. If it consists of a plant part it should be gathered at the proper season and the right stage of development, it should be properly cleaned and garbled; and carefully dried and preserved so as to be perfectly sound.

But climate, soil and season, together with various other influences affect the quality of drugs to so great an extent that there are nearly always different grades of each drug. The elevation at which the plant grows may increase or diminish its medicinal value. Wild growing plants frequently differ from the cultivated as to their virtues. If to these causes of variation be now added the ignorance, or carelessness, or accidents by which the drugs are gathered too early or too late, in unsuitable weather, from plants that are too young or too old, or from unsound plants, or are badly cleaned and dried, and ill preserved, it is not a matter of surprise that there are widely differing grades of drugs.

When several grades of the same drug are simultaneously found in the market the competent, conscientious and prudent pharmacist will, of course, select the best. Sometimes the differences are so great as to be self-evident. Thus no one can fail to observe the difference between dry, sound, well-preserved, bright flowers, and mouldy, discolored ones; between lean ergot grains scarcely half an inch long and plump ergot over an inch in length; between green, healthy-looking leaves and brown or yellow, faded ones; between a sample having the proper strong characteristic odor of the drug, and one either having no odor at all or an odor not belonging to the sound drug; or between a drug full of inert stems, wood, sticks and stones, and another quite clean and free from all impurities or admixtures.

But it happens most frequently that it requires special knowledge and training, such as only well educated and experienced pharmacists possess, to distinguish between good, bad and indifferent grades of the same drug

1055. As the vegetable drugs are not only the most numer-

ous, but also the most important of the materia medica, a good
knowledge of pharmaceutical **botany** is necessary to every intel-
ligent pharmacist.

Morphology (from μορφή, "form," and λόγος, "discourse") treats
of the organs of plants and their forms, transformations, and
relations. The study of the conspicuous organs of plants (as
root, leaf, flower, seed) as to their external conformation is
also called *organography.*

Ability to distinguish between roots and stems, leaves and
flowers, fruits and seeds, etc., is acquired by the study of organ-
ography, and is a necessary preparation for the systematic study
of pharmacognosy (1051).

A fair knowledge of the minute details of plant structure, or
of the *tissues* of plants and the *cells* of which these tissues are
composed, is also necessary to the intelligent study and identi-
fication of drugs. This is called *vegetable histology*, and some-
times *micro-botany.*

Finally, the acquisition of a sufficient knowledge of botany
and pharmacognosy absolutely requires the use of scientific ter-
minology and nomenclature. *Technical terminology* is, indeed,
necessary to satisfactory progress in any scientific study. By
technical terminology is meant a system of precise words or
terms, suitable for constructing brief accurate descriptions and
for exact expressions and descriptions of facts, conditions and
ideas. A good technical term or word expresses a great deal,
and expresses it accurately. Some valuable technical terms are
so expressive that in their absence it would require a great num-
ber of words to express their meaning without ambiguity.

A right study of science serves to teach the student to use
his five senses with fidelity, and to report with accuracy what
they perceive. He learns to see all that is to be seen, not with
his imagination, but with his eyes ; and he learns also to state
just what he sees—no more, and no less. But quickness and
truthfulness of observation and reasoning must be followed by
accurate expression, and hence science has formed for itself a

language by which knowledge may be faithfully preserved, communicated and increased. That language embraces technical terminology and nomenclature in its glossary.

The term *nomenclature* is frequently used in the same sense as terminology, but nomenclature is a system of titles or names, only, whereas terminology embraces all other technical words as well as names.

1056. **Officinal** drugs, chemicals, and pharmaceutical preparations are those commonly found in the "officine."

By "officine" is meant the apothecary's shop.

Any medicinal substance or preparation usually kept in drug stores is, therefore, "officinal."

Any drug or preparation may be officinal whether official (1059) or not.

1057. **Magistral** formulas and preparations are unofficial recipes and remedies prescribed by widely recognized high medical authorities.

1058. **Extemporaneous preparations** are those not kept in stock or "ready made" but always prepared for the occasion whenever required. They are, of course, such preparations as would deteriorate if kept on hand.

1059. **Official** drugs, preparations and processes are those included in the national pharmacopœias. But an official medicine is not necessarily an officinal one (1056).

1060. **Pharmacopœias** (from φάρμακον, "medicine," and ποιέω, I "make") are books, compiled by governmental authority, or by authoritative national conventions, containing titles, definitions, descriptions, tests, formulas, and other information, directions and standards of quality, purity and strength for the medicines in common use.

1061. **The Pharmacopœia of the United States** is prepared and published by authority of the National Pharmacopœial Convention. This Convention consists of delegates appointed by the several incorporated medical and pharmaceutical colleges and societies of the United States, the American Medical Association, the American Pharmaceutical Association, and by the

Surgeon Generals of the Army, the Navy and the Marine Hospital Service. The meetings of the Pharmacopœial Conventions are held in Washington on or about the first day of May once in ten years. Pharmacopœial Conventions were thus held in 1820, 1830, 1840, 1850, 1860, 1870, 1880 and 1890.

1062. The Authority of the Pharmacopœia of the United States has been repeatedly sustained and enforced by Courts of Justice, by Congress in certain legislation, and by the Executive Departments in official orders and regulations.

1063. The Objects of the Pharmacopœia are to establish the identity of medicines, and to prescribe standards by which we may insure uniformity in the quality, strength and methods of preparation of the officially recognized drugs, chemicals and pharmaceuticals.

Uniformity in the materia medica and pharmacy is of the highest importance, for without it there can be no science in therapeutics.

The Pharmacopœia provides titles, definitions, descriptions, identity tests, purity tests, working formulas, standards of strength, etc., for medicines commonly employed.

1064. The Pharmacopœia is the *only* national authority by which the quality, purity and strength of official medicines are governed.

The several "dispensatories" and other compilations and commentaries are valuable according to their respective merits; but they are subordinate to the Pharmacopœia in all matters touching the official standards.

No physician and no pharmacist who has proper respect for his profession and its responsibilities can do without a copy of the Pharmacopœia of the United States. Every physician should be acquainted with it; and every pharmacist should be familiar with all its details.

1065. Pharmacy is the art of selecting and preparing medicines. Its importance is manifest and great. Without medicines the physician is powerless; without the co-operation

of a competent pharmacist his course must be either the narrow beaten path of mere routine, or doomed to disappointment and even dangers.

An accomplished physician who has had time enough to become at the same time an accomplished pharmacist must be an extraordinary person, or must have very few patients and little else to attend to.

An active physician finds it in every way disadvantageous to be his own dispenser.

A good pharmacist must be able to identify medicines, must be a good judge of the quality of drugs and preparations, know how to test medicinal substances as to their purity and strength, to prepare them properly, and to combine and dispense them accurately, safely, and well. He must know enough about the drugs and their preparations to avoid incompatibilities, overdoses and all other dangers.

The word "pharmacy" is derived from the Greek word φάρμακον, which means *medicine*.

1066. Pharmaco-Technology (from φάρμακον, "medicine," τέχνη, "art," and λόγος, "discourse,") is a treatise on the art of pharmacy, or the principles, processes, and manipulations applicable in preparing, examining and dispensing medicines.

1067. Dispensing Pharmacy is the art of combining and dispensing medicines. It is the most important of all the responsible work which the pharmacist has to do. To be an ideal dispenser of physicians' prescriptions demands many qualifications. He must be familiar with the substances to be combined or dispensed and with their properties, their behavior toward each other, and their general effects upon man. He must be generally well informed, clear headed, wide awake, and careful. He must at all times be calm, courteous, and exhibit unfailing tact. He must be scrupulously neat, prompt, deft, accurate, and conscientious.

1068. Pharmacodynamics (from φάρμακον, "medicine,"

and δύναμις, "power,") is that branch of pharmacology which treats of the quality, quantity and direction of the action or effects of medicines.

1069. Therapeutics (from θεραπεύω, to "cure") is that branch of the study of Medicine which treats of the effects and modes of action of medicinal agents, and their applications for the relief or cure of pain or disease.

1070. Posology (from πόσος, "how much," and λόγος "discourse") is the consideration of the proper quantities or doses of medicines to be administered.

A "posological table" is a tabular statement of doses.

Doses are, of course, to a certain extent arbitrary. But they vary according to the age, sex, and condition of the patient and according to the effect it is intended to produce.

A "medicinal dose" is a proper and safe dose; a "maximum single dose" is the largest dose of any particular medicine which it is considered proper and safe to administer; the "maximum daily dose" is the largest total quantity of any medicine which it is proper or safe to administer in the course of a day or of twenty-four hours. A "toxic dose" is the quantity which when given at a single dose is liable to produce dangerous or injurious effects, or death.

An "adult dose" is the full dose usually administered to a man of about 21 to 30 years.

The "dose for children" is found by dividing the age (in years) of the child at its next birthday by 24; the fraction thus obtained is the proper fractional part of the adult dose that may properly be administered to the child. Thus, if the child's age at next birthday is 6 years, divide 6 by 24, which will give $\frac{6}{24}$ or $\frac{1}{4}$, the proper dose being, therefore, $\frac{1}{4}$ of the dose for an adult (Dr. Cowling).

1071. Human Physiology is the study of the functions of the organs of the human body.

Anatomy is the study of the structure, organs and parts of the body.

Every intelligent pharmacist should know what a stomach

is, or the liver, the heart, the blood vessels, muscles, bones, joints, etc. He should also have a fair knowledge of the elements of human physiology, as of digestion, the blood, circulation, respiration, animal heat, the nervous system, etc. He should know something of hygiene, food, ventilation, etc.

He should certainly know what is meant by a tonic, cathartic, astringent, emetic, stimulant, sedative, diuretic and other common therapeutic terms.

Finally, he should know what drugs are narcotic, the safe as well as toxic doses of poisonous substances; what are the symptoms of poisoning by the common poisons, and the appropriate antidotes that should be used in such cases in the absence of a physician.

All of these things are taught in any good college of pharmacy.

1072. Toxicology is the study of poisons and their effects and proper antidotes.

Poisons are substances producing fatal or dangerous effects upon the organs of the body or their functions.

CHAPTER LXII.

THE COLLECTION OF PLANT DRUGS.

1073. The medicinal value of plant drugs depends upon various conditions, as season, climate, soil, age, and development, whether the plant is wild-growing or cultivated, the part used, manner of collection, cleaning, pruning and garbling, curing or drying, and preservation.

1074. Plant drugs are generally sensitive to exposure, and by far the greater number deteriorate so rapidly, even when carefully kept, that a fresh supply must be procured annually. The new annual supply of each drug should, of course, be procured at the season when it is in its best condition. There is a

proper annual season for gathering each plant drug, and it soon afterwards reaches the market through the drug brokers, and the *new crop* can then be obtained by the pharmacists, who ought to renew their stock of perishable drugs at that time.

Some plant drugs can scarcely be preserved through one season without material deterioration; others are difficult to procure, of good quality, at any time, owing to the carelessness with which they are gathered, cured and shipped. Among the many perishable drugs are such important ones as ergot, digitalis, erythroxylon, belladonna, pilocarpus, besides all herbs and flowers

1075. The time for gathering any plant drug is that season at which it contains the greatest proportion of its active principles.

The plant part which constitutes the drug should be well developed and perfectly sound; it should neither be so young, immature and poorly developed as to be deficient in active constituents on that account, nor should it be so overgrown or old as to have begun to degenerate.

In most cases it is safe to assume that a drug which has the fresh natural color belonging to it well preserved, and which possesses in a high degree and unaltered the peculiar odor and taste which characterize it, will prove to be of satisfactory medicinal quality. It is always true that when the drug is discolored, or its odor or taste impaired, it can not be of good quality.

1076. In many plant drugs every part of the tissues is equally active ; in others again the softer, more friable portions are more active than the tougher tissues.

Whenever the Pharmacopœia defines a drug as consisting of any given plant organ or plant part, then no other portions of the plant must accompany the drug. Thus, when the bark of a root constitutes the drug, the whole root must not be used ; when the inner bark is the drug, it would not do to use both inner and outer bark together, nor to use the bark with pieces or shavings

of wood attached; when the leaves constitute the drug, the stems do not belong to it, too ; and when the drug consists of the seeds, only, the whole fruit must not be used.

Again, when the drug is defined to be leaves of the second year's growth, this definition clearly excludes the leaves of the first year's growth as unequivocally as it excludes the root, or the leaves of an entirely different plant.

1077. To illustrate the care with which the Pharmacopœia defines plant drugs, we may quote a few official definitions :

Anthemis consists of " the flower-heads of *Anthemis nobilis* collected from cultivated plants."

Conium is defined as " the full grown fruit of *Conium maculatum*, gathered while yet green."

Calendula is defined as "the fresh flowering herb of *Calendula officinalis*."

Digitalis is " the leaves of *Digitalis purpurea*, collected from plants of the second year's growth."

Eucalyptus is "the leaves of *Eucalyptus globulus*, collected from rather old trees."

Frangula is "the bark of *Rhamnus Frangula*, collected at least one year before being used."

Juglans consists of " the inner bark of the root of *Juglans cinerea*, collected in autumn."

We also find in the Pharmacopœia such directions as the following :

Belladonna Root.—" Roots which are tough and woody, breaking with a splintery fracture, should be rejected."

Colchicum Root " which is very dark colored internally, or breaks with a horny fracture, should be rejected."

Cubeb " should not be mixed with the nearly inodorous rachis or stalks."

Ergot " should be preserved in a dry place, and should not be kept longer than a year."

Galla.—" Light, spongy and whitish-colored Nutgalls should be rejected."

Prunus Virginiana.—"The bark of the small branches is to be rejected."

Senna.—"It should be freed from stalks, etc."

1078. Roots and **rhizomes** are generally gathered in the autumn, from plants of two or three years' growth, when the plant has withered or the leaves fallen; or they are sometimes gathered in the spring before tne leaf buds expand.

They must be freed from earth; best by washing them with water.

If thick and succulent, they are cut or sliced, either transversely or longitudinally, before being dried. Thick, juicy roots must be rapidly dried at a sufficiently high temperature to prevent discoloration, mould or fermentation.

Spongy, decayed, discolored or otherwise unsound portions must be rejected.

Some roots of biennials are to be rejected if woody; but the roots of trees and shrubs are always woody.

1079. Bulbs are sometimes preserved whole, as garlic and onions; but other bulbs are sliced and dried, as squill. Whole bulbs may be kept in nets or in dry sand.

1080. Barks and **woods** are taken in the spring before the leaf buds expand. The bark from branches of two to four years' growth is generally better than younger or older bark.

Sometimes the whole bark is used, because a separation is impracticable; but whenever a separation can be effected, the inner bark alone is used. The old, dry, dead, outer corky layer is always worthless.

Barks are easily dried when well spread out over enough surface in an airy, shaded place at ordinary summer heat.

1081. Herbs, leaves and **flowers** should be gathered in clear weather when the plants are dry and free from dew.

Herbs must be fully grown, but gathered before flowering, or, if aromatic, immediately after the expansion of the flowers. Biennial herbs may generally be gathered at the end of the first summer, but sometimes (when narcotic) not until the second season.

The herbs are dried in bundles hung up on strings, or spread out in thin layers on paper or muslin in an airy, shaded place.

Leaves are treated much like the herbs. If of narcotic plants those of the second year's growth are used.

Flowers are extremely sensitive, and require to be dried with great care to preserve their natural colors. They are gathered as soon as expanded, spread out well on paper, and dried in an airy, shaded place at ordinary summer heat, being stirred or turned frequently until quite dry.

1082. **Fruits** are gathered when fully ripe, except when succulent. Hard, dry fruits are easily sufficiently cured to insure their preservation.

1083. **Seeds** must be fully developed when gathered, and are easily dried. Sometimes they are best preserved in their capsules.

1084. When sufficiently dried the plant drugs should be put into suitable receptacles, such as tin cans, or tightly closed bottles, or well made drawers with snugly fitting covers.

They must be protected against light, exposure to the air or to moisture, and against too high temperature. In other words, plant drugs must be kept in well closed receptacles in a moderately warm, shaded place.

CHAPTER LXIII.

THE CHEMICAL CONSTITUENTS OF PLANT DRUGS.

1085. The **proximate principles** of plant drugs are the several kinds of chemical constituents naturally formed and contained in plants and separable from the plant parts as well as from each other by the aid of different solvents.

1086. The Classification of Plant Constituents.—The proximate principles of plant drugs may be grouped into a limited number of classes, as follows :

1. **Cellulin** (or cellulose) and its modifications, as *lignin* etc. (1090).

2. **Starches,** or amylaceous substances (1092).

3. **Gums,** or vegetable **mucilages** (1093).

4. **Pectinous** substances (1099).

5. **Sugars,** or saccharine substances (1100).

6. **Albuminous substances,** or vegetable albumin (1104).

7. **Fixed oils,** or fats (1105).

8. **Organic acids** (1111).

9. **Volatile oils** (1112).

10. **Resins** (1118).

11. **Neutral principles** not belonging to any of these other classes (1125).

12. **Alkaloids** (1128).

1087. Of these twelve classes of proximate principles only cellulin (or cellulose) in its various forms is entirely insoluble in all the ordinary simple solvents, such as water, alcohol, ether, benzin and chloroform.

All the other classes of proximate principles are soluble in one or more of the solvents named, and can, therefore, be *extracted* from the drugs in which they are contained.

1088. The Inert Constituents of Plants.—The substances belonging to either of the first eight classes enumerated (1086) exhibit no decided medicinal action ; they are either absolutely inactive or have but a very mild effect.

1089. The **Active Principles** of plants are either volatile oils, resins, neutral principles belonging to class 11 (1086), or alkaloids.

Many plant drugs contain but one "active principle"; others two, or three, or more. In a drug containing several active constituents, all of them may belong to the same class of proximate principles, or each may belong to a different class.

1090. Cellulin and **lignin.**—The substance of which cell walls, cell membranes, and fibres are constructed is called *cellulin* or *cellulose,* and it occurs in various modifications and forms. *Lignin* is the altered cellulin which constitutes *wood* and *woody fibre.*

Plant drugs containing large quantities of woody fibre are called *fibrous*, and their powders are *fibrous powders.*

Woody roots are *tough* because of the large proportion of lignin they contain.

1091. As the other proximate constituents of plants are contained in the little closed sacs or cells, which are made up of cellulose, or in the little spaces between those cells, or in canals, cavities or vessels bounded by cell walls or cellular tissues, it follows that whenever the extractable substances are to be removed from any drug consisting of plant organs, or when its soluble matters are to be extracted, the solvent used must either be capable of passing through the vegetable membranes into the closed cells and other cavities, dissolving the substances contained within them, and then passing out again carrying with it the dissolved matters, or, if the solvent can not thus pass through the membranes, the drug must be disintegrated so that the solvent can come in direct contact with the proximate principles when the cells and intercellular spaces shall have been broken open.

1092. **Starches** or amylaceous substances are contained in numerous plant drugs. You are acquainted with corn starch, laundry starch, arrow root, and perhaps other kinds of starch. Similar starches are found in drugs.

Starch consists of little granules so small that they can be well seen only with the aid of a good microscope. The size, form and markings of the starch granules differ according to the plant in which the starch is contained. Hence many drugs may be identified by their peculiar starch granules.

Starch in its normal condition is insoluble in water, alcohol, ether and other simple solvents. But when starch is heated it is altered in properties and becomes soluble. With hot water

it forms a translucent mucilaginous solution or paste, according to the proportions of the two ingredients. When boiled with water to which a little sulphuric acid has been added, the starch is converted into *glucose* (1101).

When dry starch is subjected to high heat it is converted into a gummy, water-soluble substance called *dextrin*.

1093. Gums.—Two gums are contained in the Pharmacopœia. They are acacia and tragacanth. But there are several so-called *mucilaginous drugs* in the official materia medica. " Mucilaginous drugs " are drugs containing considerable quantities of gum and from which mucilages or mucilaginous infusions can be made. Thus the Pharmacopœia contains mucilages made of quince seed, sassafras pith and slippery elm bark, as well as mucilages of acacia and tragacanth. There are also other drugs containing large quantities of gum or vegetable mucilage, as, for instance, althæa, flaxseed, senna, buchu, etc.

1094. Gum, or vegetable mucilage, is a substance which either dissolves or swells in water, forming, if the quantity of gum is sufficient, a thickish, viscous, sticky solution, or a jelly-like paste, called a mucilage. The various kinds of gums, differing according to their source, are grouped into two classes: 1, those which, like acacia, are entirely soluble in water, forming perfect or homogeneous solutions; 2, those which, like tragacanth, simply absorb a large quantity of water, swelling in it so as to form translucent gelatinous masses or pastes, but do not form perfect or homogeneous solutions.

1095. Nearly all plants and plant drugs contain more or less gum or vegetable mucilage, which is formed by the metamorphosis of plant tissues, as, for instance, of seed coats, on the inner surface of inner barks, etc.; or, in large accumulations, by the breaking down of plant tissue.

1096. Gum is hard when dry; does not soften, but, on the contrary, hardens when heated, and if the temperature is raised higher the gum becomes decomposed charred or carbonized, but does not ignite and burn with a flame.

Gums in solution readily ferment or become sour.

Gum is insoluble in alcohol, ether, chloroform, volatile oils and fixed oils.

1097. The term " gum " is very generally misapplied. Thus we hear camphor, aloes, opium, guaiac, copal, kino, catechu, asafœtida, and many other substances called gums. But nothing that is soluble in alcohol or diluted alcohol can be a gum.

1098. Gums and mucilaginous drugs are used for preparing demulcent drinks and injections, to hold insoluble substances in suspension in mixtures, as binding excipients in pill masses and troches, etc.

1099. Pectinous substances are contained in very many fruits, and often also in other plant parts. The most striking property of pectin is that it forms jelly. Jellies can be made of fruits because they contain so much pectin. Pectin is, like gum, water-soluble, but not soluble in alcohol, and it readily undergoes fermentation.

1100. Sugars of various kinds exist in plants, and also in animal substances, as in milk and honey. They are more or less sweet to the taste, cane sugar being the sweetest, and milk sugar the least sweet.

Sugars are always water-soluble, but milk sugar is not freely soluble in water, while other sugars dissolve in such large proportion as to form very thick *syrups*.

Sugar is also alcohol soluble to a limited extent. A saturated water solution of sugar can be mixed with alcohol without separation of the sugar from its solution.

1101. Ordinary white sugar is " cane sugar," *saccharose*, or *sucrose*. Beet-root sugar, sorghum sugar and maple sugar are precisely the same kind of sugar as that obtained from the sugar cane; but maple sugar is mixed with other substances derived from the maple sap which give it its peculiar agreeable flavor; when purified it can not be distinguished from cane sugar, nor can pure sorghum sugar and pure beet root sugar be recognized as in any manner differing from the refined sugar of the sugar cane.

Rock candy is crystallized cane sugar or saccharose. Milk sugar is also crystallizable.

Grape sugar is the non-crystallizable sugar contained in grapes and many other fruits. It is also frequently called *glucose*. But the term "glucose" is now generally applied to the sugar manufactured from starch (1092).

The saccharine substances used in pharmacy include: cane sugar, milk sugar, honey and manna.

1102. Sugars belonging to the class known as "glucoses" have the composition $C_6H_{12}O_6$, and readily undergo fermentation. Sugars belonging to the class called "saccharoses" have the composition $C_{12}H_{22}O_{11}$, and do not ferment unless first changed into glucose sugar.

The products of the fermentation of sugar are alcohol and carbon dioxide.

But fermentable sugar does not undergo fermentation when in the form of very dense syrup, while even cane sugar rapidly passes through the glucose stage and ferments if in the form of a weak water-solution. In fact a syrup of sugar, or simple syrup made of pure white sugar, will keep in warm weather only if so strong as to contain nearly two-thirds sugar. The official "syrup" is a solution of 65 pounds of sugar in 35 pounds of water, and is not too concentrated, for it would ferment in the summer season if weaker.

Contact with air is a necessary condition to the fermentation of sugars. A weak solution of sugar ferments because it dissolves air; but a dense syrup can not contain air and, therefore, does not ferment.

1103. Sugar is used in pharmacy and medicine for three purposes: 1, as a diluent; 2, to sweeten medicinal preparations; 3, to preserve organic medicinal substances from fermentation and other chemical changes. Both ordinary sugar (cane sugar and beet sugar) and milk sugar are used as diluents of powders.

Sugar is much used to sweeten medicinal preparations, as in lozenges, confections, syrups, mixtures, etc.

It preserves moist drugs and preparations by taking up the moisture forming a thick syrup or a coating of sugar by which the moist organic matter is enveloped and air excluded.

1104. Albuminous matters are nitrogenous substances soluble in water when in their normal condition but *coagulating* when heated. A typical example of albumin is furnished by the white of egg; as taken from a fresh egg it is transparent, liquid, and water-soluble; but when boiled it becomes white, opaque, solid, insoluble, and this change is called *coagulation*. There are similar substances contained in plant drugs and called *vegetable albumin*, or *albuminoids*. The white fleshy portion of the almond is a vegetable albumin which has received the name *emulsin*, and sometimes the name *synaptase*.

Albuminous substances do not ferment, but they undergo putrefaction. Their presence in certain pharmaceutical preparations is, therefore, to be avoided, and they may be coagulated and removed by heat, or by the use of alcohol in which albumin is insoluble.

1105. Fixed oils or fats.—There are many different kinds of fixed oils or fats employed in pharmacy and medicine, especially in the preparation of ointments, cerates, liniments, suppositories, etc. Fats are also used in the manufacture of soaps.

Among the most familiar examples of fixed oils or fats are: lard, butter, suet, tallow, wax, spermaceti, lanoleum, cacao butter, lard oil, cotton seed oil, mustard seed oil, olive oil, castor oil, cod liver oil, flaxseed oil, etc.

1106. Fixed oils are all absolutely insoluble in water; with rare exceptions (castor oil and croton oil) they are but slightly soluble in alcohol, readily soluble in ether, disulphide of carbon, benzol and benzin; and they form true *soaps* with the alkalies.

Nearly all the common fixed oils or fats consist chiefly of the oleate, stearate and palmitate of glyceryl. *Glyceryl* is a tri-valent hydrocarbon radical C_3H_5. Its hydrate is familiar to us under the name of *glycerin*, $C_3H_5(OH)_3$. The oleate of glyceryl is often called *olein*, and olive oil is nearly all oleate of glyceryl, or olein. Chemically considered the oleate of glyceryl is a

salt. It is a very fluid fat, and all liquid fats or fixed oils contain it, their fluidity being proportional to the percentage of olein, while the solid fats contain greater proportions of the stearate of glyceryl (stearin) and palmitate of glyceryl (palmitin).

Oleic acid, stearic acid and palmitic acid, are always made from fats; their glyceryl salts are the true fats; their salts with potassium and sodium are soft or hard *soaps;* and their salts with the heavy metals are the true *plasters.*

When perfectly pure the fats are usually colorless or white, odorless, tasteless, perfectly bland, without any medicinal effect. They always have a greasy or unctuous feel, are lighter than water so that they always float upon it, and they are non-volatile or fixed so that they can not be distilled, and when dropped upon clean white paper, leave a permanent stain.

1107. The liquid fixed oils or fats are classified into *drying oils*, and *non-drying oils.* The drying oils harden or dry upon exposure to the air in thin layers, as is the case with flaxseed oil; the non-drying oils like oil of almond never dry or harden.

1108. Castor oil is a remarkable fixed oil because unlike all other fixed oils it is entirely soluble in or miscible with strong alcohol in all proportions forming perfectly clear mixtures. Croton oil, when old, is also soluble in alcohol to a considerable extent but forms turbid solutions or mixtures with it.

1109. Under the combined influence of moisture, air, and warmth most of the oils become *rancid*, especially the *animal fats.* When oleic acid, lard, and other fatty substances become rancid they contain *oxyoleic acid*, have an offensive odor, and are *irritant* instead of bland. They are then unfit for any medicinal uses.

1110. Fixed oil is always contained in seeds. Hence drugs consisting of seeds sometimes require special treatment in making solid extracts and other pharmaceutical preparations of them, for if their active constituents are such as require a strongly alcoholic menstruum for their extraction a considerable quantity of fixed oil or grease will also be simultaneously dissolved by the menstruum, and the product rendered greasy. Weak alcohol does not extract the fixed oil. But the fat may often be

removed from the seed with ether, before extracting the medicinal constituents; or if the fixed oil is extracted by the alcohol together with the active constituents, it can be separated from the product afterwards.

IIII. **Organic acids** are contained in all plants. In some fruits there are large quantities of *fruit acid*, as tartaric, citric, malic, succinic and oxalic acids. But these acids do not possess any decided medicinal action, except that their salts are laxative or cathartic, or are used as cooling drinks or fever-mixtures, or as mild diuretics.

Other organic acids occurring in comparatively small quantities are numerous in the plant world, but there is no important plant drug possessing decided physiological effect that has been shown to owe its medicinal action to any organic acid.

1112. **Volatile Oils** are a numerous and mixed class of substances widely distributed among the plants. They seem to occur in nearly all plants, although generally in extremely small amounts, and although they are more common and abundant in certain fruits and flowers, they occur also in leaves and all other plant parts.

The volatile oils contained in the Pharmacopœia are many and include such typical representatives of the whole class as the oils of: turpentine, lemon, orange, anise, peppermint, cinnamon, sassafras, cloves, wintergreen and camphor.

There are also many drugs containing volatile oils as their most important constituents, as, for instance: cloves, cardamom, buchu, eucalyptus, etc.

1113. Volatile oils are generally liquid at ordinary temperatures, have an aromatic odor, are very slightly soluble in water but generally readily soluble in alcohol and ether, they have a pungent taste, and are volatile so that they can be easily distilled and do not leave a permanent stain when dropped on paper.

Volatile oils are also called " essential oils," and "ethereal oils," and the terms " otto " and " attar " have recently been proposed to distinguish volatile oils from fixed oils. There

is no similarity between fixed oils and volatile oils except that both have an "oily appearance" and are immiscible with water. Volatile oils are not salts; they contain neither glyceryl nor fat acids. But a large number of the volatile oils are saturated hydrocarbons of the series called *terpenes*, having the formula $(C_{10}H_{16})_n$; other volatile oils are oxidized hydrocarbons, and some volatile oils contain sulphur, cyanogen, and other radicals.

Most of the volatile oils are lighter than water; but some of them, as the oils of cloves and wintergreen, are heavier.

1114. Many of the volatile oils consist of a liquid portion called the *elæopten*, and another portion called the *stearopten*, which is solid when separated from the elæopten. The stearoptens of volatile oils are often called camphors, and ordinary camphor is a stearopten.

As a rule a volatile oil is not a single definite substance, but a mixture of several different kinds of substances.

1115. Most of the volatile oils of the terpene series, if not all of them, deteriorate rapidly unless kept in small, filled, tightly stoppered bottles in a dark, cool place. If exposed to air, light and warmth they *resinify*—that is, they take up oxygen, and as they are oxidized resinous products are formed by which the volatile oils are changed in composition, color, density and odor.

1116. Volatile oils are obtained from the plants and plant parts either by distillation (with the aid of water), or by expression, or by extraction with alcohol or with fixed oils.

1117. Nearly all flowers, fruits, herbs, leaves, and other plant parts possessing an aromatic odor contain one or more volatile oils, to which their odor is due. All volatile oils, and plant drugs containing them, are aromatic stimulants, and some of them are anthelmintics, while nearly all act upon the kidneys.

1118. **Resins** are solids or semi-solids, they soften and then liquefy when heated; they are non-volatile, readily combustible, being easily ignited, burning with a sooty, smoky flame; insoluble in water, always alcohol-soluble, and often also soluble

in ether, benzin, volatile oils, fixed oils, and chloroform. They
are generally weak acids, and formed by the oxidation of volatile
oils. They do not contain nitrogen.

Resins may be classified into dry, *hard resins*, which are gen-
erally amorphous and of a glassy fracture, though sometimes
crystalline, and as a rule not acrid or irritating when applied to
the skin; and *soft resins,* which are usually acrid, non-drying.

Some of the acrid resins are hard, however. There are sev-
eral resins so acrid as to vesicate the skin. Other resins are
cathartics.

1119. Resins are used in the preparation of some plasters,
cerates and even ointments. Solutions of resins in oil of tur-
pentine, benzin, or alcohol are *varnishes*.

Resins, being weak acids, form soap-like compounds called
resin-soaps with the alkalies.

1120. Among the common resins are ordinary "rosin,"
copal, dammar, mastic, sandarac, guaiac resin, scammony, amber,
benzoin, shellac, so-called "spruce-gum," burgundy pitch, etc.

1121. As the resins are formed by the oxidation of volatile
oils, and as the volatile oils are mixtures, the resins thus pro-
duced are also mixtures. Moreover, resins and volatile oils are
commonly associated together. *Oleoresins* are mixtures of vola-
tile oil and resin; thick turpentine, Canada turpentine, copaiba,
etc., are oleoresins. *Balsamic resins* are such resins as contain
either benzoic or cinnamic acid, or both, as benzoin and tolu;
and *balsams* are fluid balsamic resins, as "balsam of Peru and
storax."

1122. *Spices* are drugs containing agreeable pungent oleo-
resins, or pungent resins, or pungent volatile oils. They are
mostly oleoresinous drugs. But there are also several oleo-
resinous drugs which are used solely for medicinal purposes and
are not spices or condiments.

Capsicum, pepper, cubeb, asarum, aspidium, cypripedium,
iris versicolor, ginger, lupulin, are oleoresinous drugs.

1123. **Gum-resins** are mixtures of gum and resin, and they
usually also contain small quantities of volatile oil, which is fre-

quently the only constituent of any medicinal value. The gum-resins of the Pharmacopœia are ammoniac, asafœtida, galbanum, gamboge and myrrh.

1124. *Coloring matters* are very generally of a resinous nature. Thus the green coloring matter of leaves, called *chlorophyll*, is resinous, alcohol soluble, insoluble in water. Other coloring matters — red, yellow, and brown — are more frequently alcohol soluble than water soluble. Hence alcoholic tinctures and extracts are as a rule more highly colored than aqueous preparations.

1125. Neutral principles, not belonging to any of the different classes of proximate principles enumerated in this chapter, are of a very miscellaneous chemical character. They are often of the class known as glucosides (977), sometimes weak acids, sometimes other compounds.

As to their physical properties many neutral principles are crystallizable while others are amorphous ; many are water-soluble and a still greater number soluble in diluted alcohol or in undiluted alcohol, but others may be insoluble in one of these liquids.

A large number of the neutral principles are purely bitter stomachic tonics ; others are acrid, or even narcotic ; and others, again, seem to be wholly inert, as, for instance, *asparagin.*

The Glucosides possess medicinal activity more frequently and more decidedly than other neutral principles contained in plant drugs.

Among the most common neutral principles of plant drugs are salicin, populin, phlorizin, amygdalin, saponin, coumarin, aloin, cathartin, and elaterin; and among the important drugs whose active principles belong to this class are rhubarb, senna, senega, squill, digitalis, brayera, aloes, and colocynth.

1126. Many of the *acrid drugs*, such as squill, digitalis, senega, etc., are drugs containing glucosides. But there are also acrid drugs which owe their acridity to acrid soft resin or some acrid volatile oil, or to some acrid alkaloid.

1127. Astringent Drugs contain tannin. Tannin, or tannic acid, is a peculiar neutral principle or a weak acid, having a powerfully astringent effect. Tannin darkens iron salts, and forms insoluble compounds with all metallic salts. Ink is made by mixing decoction or infusion of nutgall or madder (containing tannin) with solutions of sulphates of iron. Tannin also has the property of tanning hides, forming a tough substance called leather when it acts upon the tissues of the fresh rawhide. Insoluble compounds are formed by tannin also with a number of other organic substances, as gelatin, alkaloids, etc.

Among the most important of our astringent drugs are tannin itself, nutgall, oak bark, logwood, catechu, kino, krameria, geranium, rubus, rhus glabra, and uva ursi.

1128. Alkaloids are the most powerful of all the active principles of plant drugs.

Alkaloids are organic bases having an alkaline reaction on test paper and capable of combining with and neutralizing the acids to form salts. They are called *alkaloids* because they resemble the alkalies in the before-mentioned properties.

1129. Many alkaloids are formed and contained in growing plants; others are not found in the living plants but formed by certain reactions in the contents of plant juices after death, as when morphine and the other opium alkaloids are formed during the process of drying the juice of the poppy capsule.

Among the most important of our alkaloids are quinine, morphine, strychnine, atropine, cocaine, physostigmine, and aconitine. Among the most important drugs whose medicinal value depends upon alkaloids we have aconite, belladonna, coffee, cinchona, colchicum, conium, erythroxylon, gelsemium, hydrastis, hyoscyamus, ipecacuanha, lobelia, nux vomica, opium, physostigma, pilocarpus, sanguinaria, stramonium, tobacco, and veratrum viride.

Over two-thirds of all known plant drugs containing alkaloids are poisonous.

1130. Alkaloids in the free state are generally alcohol-soluble, rarely water-soluble; but their salts with the stronger

acids are generally water-soluble, not generally alcohol-soluble.

Alkaloids and their salts are bitter or acrid to the taste.

They may be classified according to their chemical composition into two groups ; 1, the *amines*; and 2, the *amides*.

The **amines** consist of carbon, hydrogen and nitrogen, and are called *ternary alkaloids* for that reason. They are liquid, volatile, odorous. Nicotine (the alkaloid of tobacco), coniine (the alkaloid of conium), and lobeline (the alkaloid of lobelia), are amines.

The **amides** contain oxygen as well as carbon, hydrogen, and nitrogen. They are accordingly called oxygenated or *quaternary* alkaloids. They are solids, not volatile, odorless. By far the greater number of alkaloids belong to this class.

CHAPTER LXIV.

ROOTS, RHIZOMES, CORMS AND BULBS.

1131. Aconitum. ACONITE.

From *Aconitum Napellus* (*Ranunculaceæ*).

Mountain districts of Europe and America.

Tuberous, tapering, about 2 in. long, ½ to ¾ in. thick at the top; very dark grayish-brown exteriorly, whitish interiorly; odorless; taste first insipid, afterwards acrid; produces tingling and numbness in the throat.

Active principle—The alkaloid *aconitine*.

A cardiac sedative.

Dose of the drug 1 to 2 grs.; Abstract, ½ to 1 gr.; Extract, ⅛ to ½ gr.; Fluid Extract, ½ to 2 min.; Tincture, 1 to 5 min.

Poisonous effects.—The action of an overdose is rapid. Weakness, stupor, and paralysis are the successive symptoms.

Death results from paralysis of the muscles of respiration and of the heart.

Antidotes.—The patient should lie down, the stomach be emptied, and alcohol, ether, or spirit of ammonia administered.

1132. Allium. GARLIC.

The fresh bulb of *Allium sativum* (*Liliaceæ*).

The garlic consists of about 8 wedge-shaped bulblets.
Strong, offensive odor and a disagreeable, acrid taste.
Contains acrid volatile oil.

1133. Althæa. MARSHMALLOW.

From *Althæa officinalis* (*Malvaceæ*).

Continental Europe.

Cylindrical, or nearly so, 3 to 6 in. long, ½ in. in diameter, deep-wrinkled; decorticated, white, fibrous, starchy; odor faint; taste sweetish, mucilaginous.

Demulcent.

1134. Aspidium. MALE FERN.

The rhizome of *Aspidium Filix-mas* and *A. marginale* (*Filices*).

All temperate countries.

Pieces about 3 to 6 in. long, about ½ to ¾ in. thick; either peeled or covered with the remnants of the stipes; should be pale green, all brown portions to be removed; odor disagreeable though faint; taste slightly astringent, bitterish, acrid, disagreeable.

Contains volatile oil, resin, fixed oil and *filicic acid*.

It is a *tænicide*.

The **Oleo-resin** is the only official preparation; dose, 10 to 30 min.

1135. Belladonnæ Radix. BELLADONNA ROOT.

From *Atropa Belladonna* (*Solanaceæ*).

Central and Southern Europe.

Long, generally tapering pieces, ½ in. or more thick, wrinkled length-wise; grayish exteriorly, whitish interiorly; odor faintly narcotic; taste bitterish, finally acrid; should break with a nearly smooth fracture; tough, woody, splintery roots are to be rejected.

Active principles.—The alkaloids *atropine*, *belladonnine* and *hyoscyamine*. Mydriatic, anodyne, antispasmodic, cardiac and vaso-motor stimulant.

Dose.—Fluid extract, 1 to 3 min.

Poisonous effects.—Headache, vertigo, greatly disturbed vision, delirium, motor paralysis, stupor, convulsions

Antidotes.—Evacuation of the stomach, followed by the administration of opium, morphine or physostigma.

1136. Calamus. SWEET FLAG.

The unpeeled rhizome of *Acorus Calamus* (*Araceæ*).

The United States. Europe.

Long pieces, about ½ in. thick, wrinkled lengthwise; exteriorly brownish, interiorly whitish· spongy, fracture short; odor aromatic; taste sweetish, bitterish, pungent.

Contains volatile oil, resin and the bitter principle *acorin*.

Aromatic stimulant and tonic.

Dose of the Fluid Extract, 15 to 60 minims.

1137. Calumba. COLUMBO.

The root of *Jateorrhiza Calumba* (*Menispermaceæ*).

Eastern Africa.

Circular slices, 1 to 2 in. diameter, about $\frac{1}{6}$ to$\frac{1}{2}$ in. thick; cut surfaces concave; outer edge brownish gray, broad surface yellowish-gray and often bright yellow near the epidermis; fracture short; odor faint; taste bitter, mucilaginous.

Constituents.—The bitter principles *calumbin, calumbic acid* and *berberine*. Also starch and mucilage.

A bitter stomachic tonic.

Doses.—Fl. Extr. 15 to 75 min.; Tinct., 1 to 2$\frac{1}{2}$ fl. dr.

1138. Cimicifuga. BLACK SNAKEROOT.

Rhizome and rootlets of *Cimicifuga racemosa* (*Ranunculaceæ*).

The United States.

Rhizome short, thick, branched, covered with many long rootlets, brownish black, nearly odorless, bitter, acrid.

Contains a very acrid neutral principle and resin.

Dose. Fl. Extr., 10 to 30 minims; Tinct., 30 to 75 minims.

1139. Colchici Radix. COLCHICUM ROOT.

The corm of *Colchicum autumnale* (*Melanthaceæ*).

Middle and Southern Europe.

Ovoid, flattish, with a groove on one side. Generally sliced. Exteriorly brownish, somewhat wrinkled; interiorly white, starchy, odorless, sweetish, bitter, acrid.

Active principle.—The acrid alkaloid *colchicine*.

Alterative and diuretic.

Dose.—Extract, $\frac{1}{2}$ to 1$\frac{1}{2}$ grains; Fluid Extract, 2 to 5 minims; Wine, 10 to 30 minims.

Poisonous effects.—Pain in the stomach and bowels; watery stools; collapse.

Antidotes.—Emetics, purgatives, and afterwards opium and alcoholic stimulants.

1140. Gelsemium. YELLOW JASMINE.

Rhizome and rootlets of *Gelsemium sempervirens* (*Loganiaceæ*).

Southern United States.

Branched rhizomes about $\frac{1}{2}$ to 1 inch or more thick; rootlets longer and much thinner; brownish-yellow; tough, woody fracture; heavy odor, bitter taste.

Active principle.—The poisonous alkaloid *Gelsemine*.

A motor and sensor depressant and cardiac sedative.

Poisonous effects—Depression, respiration and heart action becoming labored; cerebral disturbance; general paralysis.

Antidotes.—After evacuation of the stomach, alcoholic stimulants, spirit of ammonia; artificial warmth and respiration; digitalis and belladonna.

1141. Gentiana. GENTIAN.

From *Gentiana lutea* (*Gentianaceæ*).

Central and Southern Europe.

Pieces about 2 to 3 inches long, ½ inch thick; thicker pieces usually split; deeply wrinkled lengthwise, more or less distinctly marked by transverse rings; exteriorly dark yellowish-brown, interiorly lighter. Brittle when dry, flexible when damp; odor characteristic, somewhat aromatic; intensified by moisture; taste bitter.

Contains the bitter principle *gentio-picrin.*

Also *gentisic acid* which darkens iron salts.

Gentian is a bitter stomachic tonic.

1142. Glycyrrhiza. LICORICE ROOT.

From *Glycyrrhiza glabra* (*Leguminosæ*).

Southern Europe.

Long, cylindrical pieces, from ¼ to 1 inch in diameter, wrinkled lengthwise, exteriorly (the bark) grayish-brown, interiorly yellow; fracture woody, coarsely fibrous; inodorous; taste sweet, leaving a somewhat acrid aftertaste.

Contains the sweet substance called *glycyrrhizin;* also starch, gum, and some acrid resin.

Preparations.—Extract, Fluid Extract, Ammoniated Glycyrrhizin. Compound Powder.

1143. Hydrastis. GOLDEN SEAL.

The rhizome and rootlets of *Hydrastis canadensis* (*Ranunculaceæ*).

The United States.

About 1½ inches long, rhizomes, ¼ inch thick, wrinkled, yellowish-gray; fracture short, orange-yellow; rootlets thin, brittle; odor faint; taste bitter.

Active Principles.—A white alkaloid, *hydrastine*, and the yellow, alkaloid *berberine*, both bitter.

Tonic, diuretic, etc.

Preparations.—Fluid Extract and Tincture.

1144. Ipecacuanha. Ipecac.

From *Cephaëlis Ipecacuanha* (*Rubiaceæ*).

Brazil.

Crooked pieces, about 3 to 5 inches long, ⅙ inch thick; dull grayish-brown, finely wrinkled, marked by numerous rings, close together, bark thick, often broken transversely; easily separated from the thin, tough, ligneous cord; odor not strong, but quite characteristic, nauseous; taste bitterish, acrid, sickening.

Active principle.—The alkaloid *emetine*.

The drug is emetic; in small doses expectorant and diaphoretic.

Doses —*Emetic:* Powder, 15 to 30 grs.; Fluid Extract, 15 to 30 minims; Syrup, 4 to 6 fluidrachms; Wine, 3 to 5 fluidrachms. *Expectorant:* Fluid extract, 1 to 4 minims; Syrup, 1 to 2 fluidrachms; Wine, 10 to 30 minims.

1145. Iris Versicolor. Blue Flag.

The rhizome of *Iris versicolor* (*Iridaceæ*).

Middle and Southern United States.

Long, jointed pieces, cylindrical or flattish, marked by scars, wrinkled, annulated, grayish-brown; taste acrid, nauseous.

Contains volatile oil and acrid resin.

Purgative and diuretic.

Dose.—Extract, ¼ to 1 gr.; Fluid Extract, 30 to 60 minims.

1146. Jalapa. Jalap.

The tuber of *Exogonium purga* (*Convolvulaceæ*).

Mexico.

Turnip-shaped, or oblong. varying in size, larger roots split, wrinkled, with short transverse ridges, dark brown, hard, heavy, interiorly pale grayish-brown; fracture smooth, resinous; odor slight sweetish, but quite peculiar, smoky; taste sweetish, acrid.

Each 100 grains of Jalap must yield at least 12 grains of resin; and not more than 1.2 grains of that resin should be soluble in ether.

Contains the cathartic resin called *Convolvulin*.

Purgative

Dose.—Powder 10 to 20 grs.; Abstract, 5 to 10 grs.; Alcoholic Extract 2 to 8 grs.: Fluid Extract, 10 to 20 minims; Compound Powder, 10 to 30 grs.; Resin, 2 to 6 grs.

1147. Krameria. Rhatany.

From *Krameria triandra* and *K. tomentosa* (*Polygalaceæ*).

Northern parts of South America.

Knotty, irregularly shaped, branched roots, sometimes about one inch or more thick; rust-brown; but the better Krameria consists of long, cylin-

drical roots not over ⅓ to ½ inch thick; dark purplish-brown; bark thick, and should constitute about one-third of the drug; wood tough, light brownish.

Contains *kramerio-tannic acid* (about 20 per cent.).

Astringent.

Dose.—Extract, 4 to 15 grs.; Fluid Extract, 30 to 60 minims; Syrup, ½ to 4 fluidrachms; Tincture ½ to 3 fluid drachms.

1148. Leptandra. CULVER'S ROOT.

From *Leptandra virginica (Scrophulariaceæ)*.

The United States.

Rhizome from 4 to 6 inches long, and about ¼ inch thick, somewhat irregular in shape, blackish-brown, with cup-shaped scars above; hard, with a woody fracture, wood yellow; rootlets thin, wrinkled, brittle; inodorous, bitter, acrid.

Contains the acrid principle called *saponin* together with acrid resin, etc.

Dose.—Extract 1 to 2 grs.; Fluid Extract 30 to 60 minims.

1149. Pareira. PAREIRA BRAVA.

From *Chondodendron tomentosum (Menispermaceæ)*.

Brazil and Peru.

Round, crooked pieces, about 4 to 10 inches long, from ¾ to 3 inches thick; exteriorly brownish-gray; furrowed lengthwise, with transverse ridges and fissures; interiorly paler brown, marked by two or more irregular, concentric circles of distinct rays.

Contains the bitter aikaloid *buxine*, also called "cissampeline," or "pelosine"

Tonic and diuretic.

Dose of Fluid Extract, 30 to 60 minims.

1150. Phytolaccæ Radix. POKE ROOT.

From *Phytolacca decandra (Phytolaccaceæ)*.

The United States.

Large, usually sliced, fleshy, wrinkled, light grayish; hard; fracture fibrous, the wood bundles in concentric circles; taste sweetish, acrid.

Active principle possibly an alkaloid. Contains acrid resin. It is narcotic.

Dose of Fluid Extract, 10 to 30 minims.

1151. Podophyllum. MANDRAKE.

Rhizome and rootlets of *Podophyllum peltatum (Berberidaceæ)*.

The United States.

Long, jointed pieces, each joint about 1½ to 2 inches long, about ¼ inch or more thick; a circular scar on the upper side at each joint, rootlets on the

under surface, or small white scars left after them; smooth or slightly wrinkled; exteriorly light orange brown, interiorly nearly whitish; odor slight, but peculiar; taste sweetish, bitter, acrid.

Contains from 4 to 5 per cent. of resin, called "resin of podophyllum," or "podophyllin," and consisting of various substances.

It is purgative.

Dose.—Powder, 8 to 30 grains; Abstract, 3 to 10 grains; Extract, 1 to 4 grains; Fluid Extract, 8 to 20 minims; Resin, 1-6 to ½ grain.

1152. Rheum. RHUBARB.

From *Rheum officinale* (*Polygonaceæ*).

Thibet and China.

Large, thick pieces of various shapes and sizes, deprived of the outer layer, exteriorly smooth, reddish-brown, covered with a light yellowish-brown powder; interiorly of an irregularly marbled appearance, orange-yellow and white veins, striæ, or rays alternating; odor peculiar, taste bitterish, somewhat astringent; when chewed, rhubarb is gritty from crystals of calcium oxalate.

Active principles.—Several resinous cathartic principles are contained in rhubarb. Among these are: *Chrysophan, chrysophanic acid, cathartin, emodin.*

Has a cathartic effect, followed by an astringent action due to *rheo-tannic acid.*

Preparations and doses.—Powder, 10 to 30 grs.; Extract, 5 to 15 grs.; Fluid Extract, ½ to 1½ fluidrachms; Compound Powder, 15 to 60 grs.; Syrup, 1 to 4 fluidrachms; Aromatic Syrup, 1 to 2 fluidrachms; Tincture, Aromatic Tincture and Sweet Tincture, each 1 to 6 fluidrachms; Wine, 1 to 4 fluidrachms.

1153. Sanguinaria. BLOODROOT.

The rhizome of *Sanguinaria canadensis* (*Papaveraceæ*).

The United States.

About two inches long, cylindrical, tapering somewhat at the ends, about ⅓ inch or more thick, somewhat wrinkled; brown-red; fracture short; taste bitter, extremely acrid.

Contains the acrid, narcotic alkaloid *sanguinarine.*

Used as an expectorant.

Dose.—Vinegar, 10 to 30 minims; Fluid Extract, 5 to 15 minims; Tincture, 10 to 60 minims.

1154. Sarsaparilla. SARSAPARILLA.

From *Smilax officinalis, S. medica*, and other species of *Smilax* (*Smilaceæ*).

Mexico, and Central and South America.

About ½ inch thick, very long, cylindrical, deeply wrinkled lengthwise, grayish brown or orange-brown ; interiorly starchy, somewhat horny ; odor very faint ; taste mucilaginous, bitterish, acrid.

The knotty rhizome or "chump," if present, should be removed.

Contains the acrid principle *saponin*, also called "parillin," or "sarsaparillin"

Alterative.

Preparations.—Fluid Extract, Compound Fluid Extract, Compound Syrup and Compound Decoction.

1155. Scilla. SQUILL.

The bulb of *Urginea Scilla* (*Liliaceæ*).

Mediterranean coasts.

Slices about 2 inches long, ¼ inch thick, yellowish-white, or reddish-white, slightly translucent, brittle when dry, tough and flexible when damp; inodorous ; taste mucilaginous, bitter, acrid.

Contains several acrid substances of which the most important are *scillitoxin*, *scillipicrin*, and *scillin*. Squill also contains much mucilage.

Diuretic and expectorant.

Dose.—Vinegar, 10 to 30 minim ; Fluid Extract, 3 to 15 minutes ; Syrup and Compound Syrup, 30 to 60 minims ; Tincture, 8 to 30 minims.

1156. Senega. SENEKA SNAKEROOT.

From *Polygala Senega* (*Polygalaceæ*).

Middle and Southern United States.

About 4 inches long, with a knotty crown, branched, spindle-shaped, somewhat tortuous, with a keel running spirally from crown to apex; Exteriorly wrinkled lengthwise, slight yellowish-brown or yellowish-gray; bark thick; odor slight, but peculiar, disagreeable; taste first insipid, sweetish, afterwards acrid.

Contains the acrid principle *saponin*, which is also called "senegin," "polygalic acid," etc.

Expectorant and diuretic.

Dose.—Abstract, 3 to 12 grains ; Fluid Extract, 8 to 20 minims ; Syrup, 1 to 2 fluid drachms.

1157. Serpentaria. VIRGINIA SNAKEROOT.

From *Aristolochia Serpentaria* (*Aristolochiaceæ*).

The Middle and Southern United States.

Rhizome about one inch long, with remnants of stems on the upper and rootlets on the under side; rootlets long, slender, brittle; dull brown, interiorly lighter; odor aromatic, camphoraceous, terebinthinate; taste warm, bitterish, resinous.

Contains volatile oil and resin.

Aromatic stimulant tonic.

Dose.—Fluid Extract, 30 to 60 minims; Tincture, ½ to 2 fluidrachms.

1158. Spigelia. PINKROOT.

From *Spigelia marylandica* (*Loganiaceæ*).

The United States.

Rhizome about 2 inches long and ⅛ inch thick; scars above, and numerous thin, brittle rootlets below; dark brown; slightly aromatic, bitter.

Contains a bitter principle, volatile oil and resin.

Anthelmintic.

Dose of Fluid Extract, 30 to 60 minims.

1159. Stillingia. QUEEN'S ROOT.

From *Stillingia sylvatica* (*Euphorbiaceæ*).

Southern United States.

Long pieces, about 2 inches thick, wrinkled, tough, grayish-brown; bark thick with numerous resin cells; odor disagreeable; taste bitter, acrid.

Contains a soft, pungent, acrid resin.

Alterative.

Dose of Fluid Extract, 1 to 2 fluidrachms.

1160. Taraxacum. DANDELION.

From *Taraxacum Dens-leonis* (*Compositæ*).

Europe and America.

About 3 to 6 inches long, ½ to 1 inch thick, branched head, wrinkled lengthwise, exteriorly dark brown when old, lighter when recently dried, interiorly yellowish, bark thick and white, with milk-vessels in concentric rings; inodorous, bitter.

Contains the bitter principle *taraxacin* and acrid *taraxacerin*.

Tonic, diuretic.

Dose.—Extract, 15 to 40 grs.; Fluid Extract, 1 to 3 fluidrachms.

1161. Valeriana.—VALERIAN.

From *Valeriana officinalis* (*Valerianaceæ*).

Europe. Vermont.

Rhizome about ¾ to 1½ inches long, brown, interiorly lighter; rootlets numerous, slender, brittle, brown, with thick bark; odor strong, peculiar, disagreeable; taste bitter, aromatic, nauseous.

Contains *valeric acid*, volatile oil and resin. When fresh it contains much volatile oil and little valeric acid; as the drug becomes older the proportion of acid increases and the volatile oil diminishes.

Antispasmodic.

Dose.—Abstract, 8 to 30 grains; Extract, 10 to 40 grs.; Fluid Extract, ½ to 2½ fluidrachms; Tincture, and Ammoniated Tincture, 1 to 4 fluidrachms.

1162. Veratrum Viride. AMERICAN HELLEBORE.

From *Veratrum viride* (*Melanthaceæ*).

Northern United States.

Rhizome about 2 to 3 inches long, 1 to 2 inches thick, exteriorly blackish-gray, interiorly grayish-white; numerous light brown rootlets, from 4 to 6 inches long and about $\frac{1}{12}$ inch thick; inodorous; powder extremely irritating, sternutatory; taste bitter, very acrid.

Active principles.—The acrid alkaloids *jervine*, *veratroidine*, *rubijervine*, and *pseudojervine*.

Cardiac sedative.

Dose.—Fluid Extract, 2 to 5 minims; Tincture, 3 to 10 minims.

1163. Zingiber. GINGER.

From *Zingiber officinale* (*Zingiberaceæ*).

Tropical Asia (Cochin) and the West Indies (Jamaica).

Rhizomes about ½ inch or more broad, flattish, lobed or branched; deprived of the epidermis; pale buff-colored; fracture fibrous, starchy, showing scattered resin cells; odor peculiar, aromatic, pungent; taste hot, spicy.

Contains volatile oil and resin.

Carminative.

Dose.—Fluid Extract, 4 to 30 minims; Oleoresin, 1 to 3 drops; Syrup, 1 to 2 fluidrachms; Tincture, 30 to 60 minims.

CHAPTER LXV.

WOODS, BARKS, ETC.

1164. Guaiaci Lignum. GUAIAC WOOD.

The heartwood of *Guaiacum officinale* (*Zygophyllaceæ*).

West Indies and South America.

Heavy, hard, dark greenish-brown, resinous; when heated it emits a resinous odor; taste somewhat acrid.

Contains about 25 per cent. *resin.*

Alterative.

Used in the preparations called Compound Decoction and Compound Syrup of Sarsaparilla.

1165. Hæmatoxylon. Logwood.

The heartwood of *Hæmatoxylon campechianum* (*Leguminosæ*).

Tropical America.

Heavy, hard, brown-red; odor faint, peculiar; taste sweetish, astringent; colors the saliva dark reddish-pink.

Contains *tannin*, and a crystallizable, sweet substance called *hæmotoxylin*. The tannin is the valuable constituent.

Astringent.

Dose of the Extract, about 10 grains.

1166. Quassia. Quassia.

The wood of *Picræna excelsa* (*Simarubaceæ*).

West Indies.

Yellowish-white chips or raspings; inodorous; intensely bitter.

Contains the bitter neutral principle *quassiin*. No tannin is contained in it.

Bitter stomachic tonic.

Dose.—Extract, 1 to 2 grs.; Fluid Extract, 30 to 60 minims; Tincture, 1 to 2 fluidrachms.

1167. Aspidosperma. Quebracho Bark.

From *Aspidosperma Quebracho* (*Apocynaceæ*).

Brazil.

Large pieces, about ¾ inch thick, more or less curved, the rough corky layer and the inner bark being of about equal thickness; outer bark fissured, gray; inner bark fawn-colored; fracture fibrous; inodorous; inner bark (active portion) very bitter.

Active principles:—Several alkaloids, the most important of which are *aspidospermine* and *quebrachine*.

Dose of Fluid Extract, 15 to 45 minims.

1168. Aurantii Amari Cortex. Bitter Orange Peel.

The rind of the fruit of *Citrus vulgaris* (*Aurantiaceæ*).

Southern Europe.

Thin, spiral bands or oval, curved pieces, greenish-gray and reddish on the outer surface, white on the inner side. Odor agreeable, aromatic; taste aromatic, bitter.

Constituents.—The bitter principle *hesperidin* and a little *volatile oil*. (This volatile oil is known in commerce as "essence de bigarade.")

Used as an aromatic, bitter, stomachic tonic.

Dose.—Fluid extract, 30 to 60 minims; tincture, 1 to 2 fluid drachms.

1169. Cinchona. Cinchona Bark.

The bark of any species of *Cinchona* (*Rubiaceæ*), containing at least three per cent. of total alkaloids.

Cinchona Flava. Yellow Cinchona; Calisaya Bark; Yellow Peruvian Bark.

The trunk bark of *Cinchona Calisaya*.

Peru and Bolivia.   Cultivated in India.

Cinchona Rubra. Red Cinchona; Red Peruvian Bark. From *Cinchona Succirubra*.

Ecuador.   Cultivated in Java, Ceylon, etc.

The Pharmacopœia recognizes under the general title of " Cinchona " any cinchona bark containing at least 3 per cent. of the total cinchona alkaloids; it requires the " yellow cinchona " and " red cinchona " to contain at least 2 per cent. of the alkaloid quinine, without reference to the other cinchona alkaloids.

Yellow Cinchona occurs in flat pieces or quills of various sizes, of a light yellowish-brown color; inodorous; taste bitter.

Dose.—Extract, 10 to 30 grains; Fluid extract, 15 to 50 minims; Infusion, 6 to 24 fluidrachms; Tincture, ½ to 2 fluidrachms.

Red Cinchona occurs in quills, irregular pieces, or in shavings; dark brown red; odor faint; taste bitter, astringent.

Dose.—Fluid Extract, 15 to 60 minims; Comp. Tincture, ½ to 2 fluid drachms.

Constituents.—Both yellow and red cinchona contain the alkaloids *quinine, quinidine, cinchonine* and *cinchonidine;* but yellow bark contains a greater proportion of quinine than the red bark, while red cinchona contains a greater proportion of cinchonidine and cinchonine. Both barks contain a peculiar tannin called *cinchotannic acid.* The red bark contains also a resinous coloring matter called *cinchona red.*

Uses.—Cinchona is a valuable bitter tonic and antiperiodic, it is also astringent.

1170. Cinnamomum. Cinnamon.—Saigon Cinnamon.

The inner bark of the shoots of some species of *Cinnamomum (Lauraceæ).*

Grown in China.

Saigon cinnamon occurs in regular quills, from ½ to nearly 1 inch in diameter, exteriorly rough, brownish-gray, light brown on the inner side; odor very fragrant, taste sweetish, aromatic, quite pungent, but agreeable.

Ceylon cinnamon is in long, slender multiple quills, consisting of the thin, smooth inner bark; of a light yellowish-brown color. It is of very fine flavor.

Chinese cassia cinnamon is thicker than Ceylon cinnamon, occurs in single quills of much thicker bark, darker brown, and of inferior flavor.

Contains *volatile oil.*

Used as an aromatic stimulant and as flavoring ingredient.

1171. Frangula. BUCKTHORN BARK.

From *Rhamnus Frangula* (*Rhamnaceæ*). Must have been collected at least one year before being used.

Throughout Europe.

Quills or troughs about ⅛ to ¾ inch in diameter, the bark about 1–24 in. thick, brittle. Outer surface smoothish, grayish or brown; inner surface smooth, orange or brownish-yellow. Odor faint but peculiar; taste sweetish, bitter, disagreeable. Colors the saliva yellow.

Constituents.—*Frangulin,* or rhamnoxanthin, which is cathartic; also several other laxative and cathartic principles of a resinous character. Old bark contains *emodin,* which is also found in rhubarb.

Purgative.

Dose of the Fluid Extract, 1 to 3 fluidrachms.

1172. Gossypii Radicis Cortex. COTTON ROOT BARK.

The bark of the root of the cotton plants, *Gossypium herbaceum* and other species of *Gossypium* (*Malvaceæ.*).

Southern United States.

Long, thin, flexible strips, brownish-yellow exteriorly, inner surface whitish; tough, fibrous; inodorous; taste somewhat acrid.

Contains *resin,* tannin, and red coloring matter.

Its medicinal properties and uses are similar to those of ergot.

Dose of the Fluid Extract, 30 to 60 minims.

1173. Granatum. POMEGRANATE ROOT BARK.

The bark of the root of *Punica Granatum* (*Granataceæ.*)

Cultivated in subtropical countries as on the Mediterranean borders.

Troughs, quills, or fragments of various sizes, mostly in pieces about two to four inches long, bark about 1–24 inch thick; outer surface yellowish-gray or brownish-gray; inner surface lighter grayish-yellow; inodorous; taste astringent, somewhat bitter. Colors the saliva yellow.

Contains the alkaloid *pelletierine,* and other alkaloids have also been reported as found in this drug.

It is anthelmintic or tænicide.

Dose of the Fluid Extract, 30 to 80 minims.

1174. Mezereum. MEZEREUM.

From *Daphne Mezereum* and other species of *Daphne* (*Thymelaceæ*).

Mountain regions of Northern Europe and Asia.

Long, thin, tough bands, exteriorly brownish-yellow and light greenish, on the inner side whitish, shining. Inodorous; extremely acrid.

Contains soft, *acrid resin*, and an *acrid volatile oil*, besides the bitter principle *daphnin*.

Preparations.—Extract, Fluid Extract and Ointment; used externally as stimulants and rubefacients.

1175. Prunus Virginiana. WILD CHERRY.

From *Prunus serotina* (*Rosaceæ*).

The United States.

Wild Cherry Bark is collected in the autumn from medium large branches of sound, not too old, trees. The bark from small branches as well as cork-covered old bark, must not be used.

Curved or flat, irregularly-shaped pieces at least 1–12 inch thick, exteriorly greenish-brown or yellowish-brown, more or less glossy, with transverse scars; inner surface light brown, sometimes striate or fissured. When dry it has a faint tan bark odor; when moistened it develops a decided odor of bitter almond. Taste astringent, bitter-almond like, and bitter.

Contains *tannin*, *amygdalin*, *emulsin*, some resin, and the bitter principle *prunin*. When macerated with water the amygdalin decomposes and yields hydrocyanic acid and a volatile oil similar to that produced from bitter almond.

It is a bitter tonic and slightly sedative. Mostly used for its agreeable flavor.

Dose.—Fluid Extract, 30 to 60 minims; Infusion. 1 to 3 fluid ounces; Syrup, about ½ fl. oz.

1176. Quercus Alba. WHITE OAK BARK.

From *Quercus alba* (*Cupuliferæ*).

The United States.

Flattish pieces, about ¼ inch thick, with corky layer removed; pale brown; with short ridges lengthwise on the inner surface; coarse fibrous fracture. A faint tan bark odor; taste very astringent. Usually coarsely ground.

Contains tannin, called *quercitannic acid*, from 6 to 15 per cent. Used as an astringent.

1177. Rhamnus Purshiana. CASCARA SAGRADA.

The bark of *Rhamnus Purshiana* (*Rhamnaceæ*).

Rocky mountains and the Pacific slope.

Thin, brittle troughs or quills of various lengths, externally brownish-gray in younger bark, the brown is mottled with nearly black alternating with

whitish or ash-colored spots; yellowish-brown or orange-yellow on the inner side. Odor faint; taste bitter, disagreeable.

Constituents similar to those of Frangula (1171).

Purgative.

Dose of Fluid Extract, 15 to 60 minims.

1178. Rubus. BLACKBERRY ROOT BARK.

The bark of the root of *Rubus villosus* and *Rubus trivialis* (*Rosaceæ*).

The United States.

Quills, troughs, or flexible bands, externally blackish-gray, inner surface light brownish; inodorous, astringent, bitter.

Contains *tannin* and is used as an

Astringent.

Dose of Fluid Extract, 1 to 2 fl. drs.

1179. Sassafras. SASSAFRAS BARK.

The root bark of *Sassafras officinalis* (Lauraceæ).

The United States and Canada.

Irregular pieces deprived of the corky layer, bright rust brown, soft, brittle, with short fracture. Odor strongly aromatic; taste sweetish, aromatic, somewhat astringent.

Contains about 3 per cent. *volatile oil*, some *resin*, and a little *tannin*. Used mainly as a flavoring constituent.

1180. Ulmus. SLIPPERY ELM BARK.

The inner bark of *Ulmus fulva* (*Urticaceæ.*)

The United States.

Flat pieces, about ⅛ inch thick, tough, pale brownish-white, fracture fibrous; odor faint, peculiar; taste insipid, mucilaginous.

Contains *mucilage.*

Demulcent.

1181. Galla. NUTGALL.

Excrescent growths upon the bark of *Quercus lusitanica,* var. *infectoria* (*Cupuliferæ*) caused by the punctures and deposits of ova made by the insect *Cynips Gallæ tinctoriæ.*

The Levant.

Subglobular, about ¾ inch in diameter, tuberculated above; heavy, hard, dark olive green or blackish-gray; fracture granular, grayish; nearly inodorous; taste, strongly astringent.

Contains from 40 to 70 per cent. *tannin*, and 2 to 3 per cent. *gallic acid.*

Powerfully astringent.

CHAPTER LXVI.

HERBS, FLOWERS, AND LEAVES.

1182. Cannabis Indica. INDIAN CANNABIS OR INDIAN HEMP.

Flowering tops of the female plant of *Cannabis sativa* (*Urticaceæ*), grown in the East Indies.

Branching, brittle, with small linear lanceolate leaflets, small pistillate flowers, and occasionally some hemp seed, the whole top resinous and sticky when warmed in the hand. Color greenish brown; odor peculiar aromatic, narcotic; taste slightly acrid.

Contains *resin* and volatile *oil*.

Intoxicant. Hypnotic.

Dose.—Extract, ⅙ to ½ gr.; Fluid Extract, 2 to 5 minims; Tincture, 8 to 30 minims.

1183. Eupatorium. BONESET.

The leaves and flowering tops of *Eupatorium perfoliatum* (*Compositæ*).

North America.

Leaves opposite, united at the base, lanceolate, 4 to 6 inches long, rough on the upper side, downy beneath; flowers numerous, in corymbs, florets white; odor aromatic; taste bitter, astringent.

Contains *volatile oil*, the bitter *eupatorin*, and a little tannin.

Emetic, diaphoretic.

Dose of Fluid Extract, 15 to 60 minims.

1184. Grindelia. GRINDELIA ROBUSTA.

Flowering tops and leaves of *Grindelia robusta* (*Compositæ*).

West of the Rocky Mountains, especially in California.

Leaves about two inches long, narrow, pale green, brittle; heads many-flowered, about one-half to three-fourth inches in diameter; flowers yellow, the whole top resinous; odor aromatic; taste pungent, aromatic, bitter.

Contains *volatile oil* and *resin*.

Stimulant, diuretic.

Dose of Fluid Extract, 30 to 60 minims.

1185. Lobelia. INDIAN TOBACCO.

Leaves and tops of *Lobelia inflata* (*Lobeliaceæ*), collected after a portion of the capsules have become inflated.

The United States.

Leaves alternate, oblong, about two inches long, pale green; flowers pale blue; odor slight; taste acrid, nauseating.

Active principle, the volatile alkaloid *lobeline*.

Emetic, powerfully depressant, narcotic.

Dose.—Vinegar of Lobelia, 15 to 60 minims; Fluid Extract, 3 to 30 minims; Tincture, 10 to 45 minims. Much smaller doses are given when the drug is used as an expectorant.

1186. **Marrubium.** HOARHOUND.

The leaves and tops of *Marrubium vulgare* (*Labiatæ*).

Europe and America.

Leaves about one inch long, opposite, ovate, obtuse, downy above, hairy beneath, flowers white in whorls; odor slight, herbaceous; taste bitter, aromatic.

1187. **Mentha Piperita.** PEPPERMINT.

The leaves and tops of *Mentha piperita* (*Labiatæ*).

Cultivated in North America and Europe.

Leaves about 2 inches long, pointed, stems quadrangular, flowers small, purplish; odor peculiar, aromatic; taste pungent and cooling.

Contains *volatile oil.*

Stimulant.

1188. **Anthemis.** CHAMOMILE.

The flower-heads of *Anthemis nobilis* (*Compositæ*), from cultivated plants.

Cultivated in Europe.

Subglobular, about ¾ inch broad, florets white; odor aromatic, peculiar, taste aromatic, bitter.

Contains *volatile oil.*

Stimulant.

1189. **Arnicæ Flores.** ARNICA FLOWERS.

The flower-heads of *Arnica montana* (*Compositæ*).

Europe and North America.

About 1⅛ inches broad, florets yellow, pappus hairy; odor feeble, aromatic; taste bitter, acrid.

Contains *volatile oil.*

Used only externally.

1190. **Brayera.** KOOSSO.

The female inflorescence of *Brayera anthelmintica* (*Rosaceæ*).

Abyssinia.

Clusters of panicles of reddish flowers; odor feeble, tea-like, reminding of elder flowers; taste bitter, disagreeable, acrid.

Contains the bitter resinous principle *Koossin*. Anthelmintic.

Dose.—Powder, 2 to 4 drachms; Fluid Extract, 1 to 4 fluid drachms; Infusion, one pint.

1191. Caryophyllus. CLOVES.

The unexpanded flowers of *Eugenia caryophyllata* (*Myrtaceæ*) Africa.

A little over ½ inch long, consisting of a calyx mounted by four spreading sepals, surrounding the four petals which overlap each other forming a globular bud about ⅛ inch in diameter; color, rich brown; odor, strongly aromatic; taste, aromatic, pungent. Volatile oil exudes when the clove is scratched or indented by the nail.

Contains from 15 to 20 per cent. *volatile oil*, which is the most valuable constituent.

Aromatic and stimulant.

1192. Crocus. SAFFRON.

The stigmas of *Crocus sativus* (*Iridaceæ*).

Austria, Spain, France, Italy, etc.

Separate, or three together attached to a portion of the style; the stigmas are thread-like, about 1¼ inch long, flattened and notched at the top, soft, flexible, of a rich orange brown color; odor, decided, peculiar, agreeable, aromatic; taste, aromatic, bitterish. Colors the saliva a deep golden-yellow.

Contains *volatile oil* as its most important constituent.

Used as a flavoring ingredient and a coloring agent, but is stimulant and diuretic.

Dose of the Tincture, 1 to 2 fluid drachms.

1193. Lavandula. LAVENDER.

The flowers of *Lavandula vera* (*Labiatæ*).

Cultivated in Europe.

Small, with tubular blue-gray calyx, violet-blue corolla; odor fragrant; taste bitterish, aromatic.

Contains volatile oil.

Stimulant, used mainly as an aromatizing ingredient.

1195. Rosa Gallica. RED ROSE.

The petals of *Rosa gallica* (*Rosaceæ*), collected just before the expansion of the roses. Cultivated in France.

Roundish, deep purplish red petals of a rose-like fragrance; taste, bitterish, slightly acidulous, somewhat astringent.

Contains a very small amount of *volatile oil* and a little *tannin*.

Used as a mild astringent for children.

1194. Matricaria. German Chamomile.

The flower heads of *Matricaria Chamomilla* (*Compositæ*).

Europe.

About ¾ inch broad, ray-florets white, flowers yellow; odor aromatic; taste, bitter, strongly aromatic.

Contains *volatile oil*.

Used as a diaphoretic and stomachic.

1196. Sambucus. Elder Flowers.

The flowers of *Sambucus canadensis* (*Caprifoliaceæ*).

North America.

Small, cream-colored or pale yellow; odor peculiar, aromatic; taste, sweetish, aromatic, somewhat bitter.

Contains *volatile oil* and a little acrid resin.

Stimulant and diaphoretic.

1197. Santonica. Levantic Wormseed, or German Worm-seed.

The unexpanded flower-heads of *Artemisia maritima* (*Compositæ*).

Turkestan.

Nearly $\frac{1}{12}$ inch long, ovoid, grayish-green; odor strong, peculiar; taste aromatic, bitter.

Contains the peculiar feebly acid principle *santonin*, and some volatile oil and resin.

Anthelmintic.

1198. Belladonnæ Folia. Belladonna Leaves.—From *Atropa Belladonna* (*Solanaceæ*).

Central and southern Europe.

Four to 6 inches long, broadly ovate, tapering, smooth, thin, brownish-green above, grayish-green beneath; odor faint, herbaceous; taste bitterish, unpleasant.

Active principles.—The alkaloids *atropine, belladonnine*, and *hyoscyamine*. Mydriatic anodyne (1135).

Dose.—Extract, ⅙ to ½ grain; Fluid Extract, 3 to 5 minims; Tincture, 15 to 30 minims.

Poisonous Effects and **Antidotes.**—See 1135.

1199. Buchu. Buchu Leaves.—From *Barosma betulina, B. crenulata*, and *B. serratifolia* (*Rutaceæ*).

Southern Africa.

There are two recognized varieties of the drug: LONG BUCHU from *B. betulina*, and *B. crenulata*, and SHORT BUCHU from *B. serratifolia*.

LONG BUCHU consists of narrow, lanceolate leaves, about one inch long, thin, green.

SHORT BUCHU consists of leaves about ⅜ inch long, roundish oval, obtuse, thickish, pale green.

Both kinds of leaves have serrate or crenate edges, are strongly aromatic and have a strong, pungent, bitterish taste, somewhat reminding of mint.

Contains *volatile oil*, which is the only active constituent. Mucilage is also contained in the drug.

Used as an aromatic stimulant and diuretic.

Dose of the Fluid Extract, 15 to 30 minims.

1200. Digitalis. FOXGLOVE.

The leaves of *Digitalis purpurea* (*Scrophulariaceæ*) collected from plants of the second year's growth.

Europe.

Leaves 4 to 12 inches long; oblong, crenate, wrinkled, coarsely net-veined, downy on the under side, mid-rib thick; dull green above, paler beneath; odor feeble; herbaceous; taste bitter, disagreeable.

Active Principles.—The principal active constituent is *digitoxin*. Digitalis is a heart stimulant and a diuretic.

Dose.—Powder, ½ to 3 grains; Abstract, ½ to 1 grain; Extract, ⅙ to ½ grain; Fluid Extract, 1 to 3 minims; Infusion, 2 to 5 fluid drachms; Tincture, 5 to 20 minims.

Poisonous Effects — In large doses it may cause a too powerful contraction of the heart, or tetanic spasm. Or the excitement of the heart produced by the drug may be followed by fatal exhaustion. Headache, dizziness, delirium, exhaustion, are among the symptoms of poisoning by digitalis.

Antidotes —Opium, aconite, saponin, etc. Stimulants are given to counteract depression.

1201. Erythroxylon. COCA LEAVES.—From *Erythroxylon Coca* (*Erythroxylaceæ*).

Peru.

Oval, 2 or 3 inches long, pale green, net-veined, with prominent mid-rib, and a curved line from base to apex on each side of the mid-rib; odor feeble, herbaceous; taste bitterish, slightly aromatic.

Active principle.—The alkaloid *cocaine*.

Stimulant.

Dose of Fluid Extract, 1 to 4 fluid drachms.

1202. Eucalyptus. EUCALYPTUS.

The leaves of *Eucalyptus globulus* (*Myrtaceæ*) collected from rather old trees.

Australia. Cultivated in California.

Scythe-shaped, from 6 to 12 inches long, tapering, thick, gray-green, feather-veined; odor, camphoraceous, strong; taste, pungent, aromatic, bitterish, a little astringent.

Contains *volatile oil* and *resin*.

Stimulant, diaphoretic, antiseptic, diuretic.

Dose of the Fluid Extract, 15 to 60 minims.

1203. Hyoscyamus. HENBANE.

Leaves of *Hyoscyamus niger* (*Solanaceæ*) collected from plants of the second year's growth.

Europe.

Oblong, from 4 to 10 inches long and 2 to 4 inches broad, soft, hairy, glandulous, wrinkled; have a broad, whitish, prominent mid-rib; grayish-green; odor strong, narcotic; taste bitter, acrid.

Active principles —The alkaloids *hyoscyamine* and *hyoscine*.

Anodyne, hynotic, narcotic.

Dose.—Abstract, 2 to 6 grains; Extract, 1 to 2 grains; Fluid Extract, 5 to 30 minims; Tincture, 15 minims to 2 fl. drs.

Poisonous Effects similar to those of belladonna (1135), and **antidotes** the same.

1204. Matico. MATICO.

The leaves of *Arthante elongata* (*Piperaceæ*).

South America.

They are 4 to 6 inches long, about an inch or more broad, pointed, venation very prominent on the under side, upper surface wrinkled; brittle, hairy; odor, aromatic, spicy; taste, pungent, bitterish, astringent.

Contains *volatile oil* and *resin*, and a little tannin.

Stimulant, blennhoretic, diuretic.

Dose.—Fluid Extract, 30 to 60 minims; Tincture, 1 to 4 fluid drachms.

1205. Pilocarpus. JABORANDI.

The leaves of *Pilocarpus pinnatifolius* (*Rutaceæ*).

Brazil.

About 4 inches long, oblong, obtuse, thick, grayish-green, smoothish; slightly aromatic when rubbed; bitter, somewhat pungent.

Contains the alkaloids *pilocarpine* and *jaborandine*.

Powerful diaphoretic.

Dose of the Fluid Extract, 30 to 120 minims.

1206. Rosmarinus. ROSEMARY.

From *Rosmarinus officinalis* (*Labiatæ*).

Cultivated in Europe.

Almost needle-shaped, about an inch long, dark green, strongly aromatic, pungent.

Contains *volatile oil.*

Stimulant. Rarely used.

1207. Salvia. SAGE.

From *Salvia officinalis* (*Labiatæ*). Cultivated.

About 1 to 2 inches long, oval, wrinkled, thick, soft, hairy, grayish-green; aromatic, bitterish, somewhat astringent.

Contains *volatile oil* and a little tannin.

Stimulant, slightly astringent. Used in gargles.

1208. Senna. SENNA.

There are two varieties:

ALEXANDRIA SENNA consists of the leaflets of *Senna acutifolia* (*Leguminosæ*).

Africa.

About 1 inch long and ⅓ inch broad across the middle, pointed, thick, smooth, brittle, grayish-green; odor peculiar, nauseous; taste nauseous, bitterish.

INDIA SENNA consists of the leaflets of *Cassia elongata*.

India; cultivated.

About 2 inches long, ½ inch broad, pointed, not thick, dull green (darker than the Alexandria Senna), not brittle; odor about the same as of the other variety of senna; taste mucilaginous, bitter, nauseous.

Senna should be free from stalks and other admixtures.

Contains *cathartin*, *chrysophan*, and other less important constituents.

Cathartic.

Dose.—Powder, 30 to 150 grains; Confection, 60 to 150 grains; Fluid Extract, 1 to 4 fluid drachms; Compound Infusion, 1 to 3 fluid ounces; Syrup, 1 to 4 fluid drachms.

1209. Stramonium. STINKWEED; JIMPSON WEED.

From *Datura Stramonium* (*Solanaceæ*).

North America as well as Europe.

About 6 inches long, 4 inches broad, one-third of their length from the base, unsymmetrical in outline and venation, wrinkled, thin, brittle; develop a disagreeable narcotic odor when rubbed; taste, bitter, nauseous.

Contains the alkaloids *atropine* and *hyxcyamine.*

Narcotic, anodyne, hypnotic. Effects similar to those of belladonna (1135) and hyoscyamus (1203).

1210. Tabacum. TOBACCO.

From *Nicotiana Tabacum* (*Solanaceæ*).

Cultivated in the middle Southern States of the United States, and in Cuba, etc.

Up to 20 inches long, oval, lanceolate, pointed, brown, brittle, hairy; odor, peculiar, strong, nauseous, narcotic; taste, nauseous, bitter, acrid.

Contains the poisonous volatile alkaloid *nicotine*.

Used only externally, being too dangerous for internal administration. Depressant.

1211. Uva Ursi. BEARBERRY LEAVES.

From *Arctostaphylos Uva-ursi* (*Ericaceæ*).

Northern Europe and America.

About four-fifths inch long, ½ inch broad, obovate, thick, smooth, glossy, dark green above, paler beneath, odor hearbaceous; taste very astringent, somewhat bitter.

Contains *tannin*, and some *gallic acid*, besides certain peculiar principles called *arbutin*, *ericolin*, and *ursone*.

Astringent, diuretic.

CHAPTER LXVII.

FRUITS AND SEEDS.

1212. Anisum. ANISE.

The fruit of *Pimpinella Anisum* (*Umbelliferæ*).

Cultivated in Germany, Italy and other countries.

About ⅙ inch long, ovate, greenish-gray, fine-hairy, ridged; odor, agreeable, aromatic; taste, aromatic, sweet, pungent.

Contains *volatile oil.*

Stimulant, carminative. Much employed for flavoring.

1213. Capsicum. CAYENNE PEPPER. RED PEPPER. AFRICAN PEPPER.

The fruit of *Capsicum fastigiatum* (*Solanaceæ*).

Africa, South America.

Oblong, about ½ to ¾ inch long, glossy, red membranous capsules, containing flat yellowish seeds. Odor, peculiar; taste, fiery, acrid.

Contains the volatile, acrid principle *capsaicin* together with volatile oil and acrid resin.

Used as a stimulant, carminative; externally as a counter-irritant and rubefacient.

Dose.—Fluid Extract, 3 to 8 minims; Oleoresin, ⅛ to ⅓ minim; Tincture, ½ to 1 fluid drachm.

Externally are used the Capsicum Plaster, and also the Oleoresin.

1214. **Cardamomum.** CARDAMOM.

The fruit of *Elettaria Cardamomum* (*Zingiberaceæ*).

Malabar, etc.

Ovoid, about ½ inch long, ¼ to ⅓ inch in diameter, triangular; pale buff, leathery pericarp. Seeds dark reddish-brown, very small, hard; odor, peculiar, agreeable, aromatic; taste, aromatic, pungent.

Contains volatile oil.

An aromatic stimulant and carminative. Much used for flavoring.

1215. **Carum.** CARAWAY.

The fruit of *Carum Carvi* (*Umbelliferæ*).

Cultivated in Europe.

Slender, oblong, about ⅙ inch long, dark brown; odor agreeable, aromatic; taste, sweetish, aromatic, pungent.

Contains *volatile oil*.

A stimulant, carminative, stomachic. Much used for flavoring.

1216. **Chenopodium.** AMERICAN WORMSEED.

The fruit of *Chenopodium ambrosioides* (*Chenopodiaceæ*).

Europe and North America.

Nearly globular, about $\frac{1}{12}$ inch in diameter, dull brownish-green; odor strong, peculiar, disagreeable; taste bitterish, pungent, nauseous.

Contains *volatile oil*.

Anthelmintic.

Dose.—15 to 30 grains.

1217. **Colocynthis.** COLOCYNTH.

The fruit of *Citrullus Colocynthis* (*Cucurbitaceæ*), deprived of the rind.

Spain, Western Asia.

Globular, from 2 to 3 inches in diameter, white or yellowish-white; light, porous, brittle, containing a large number of flat, brownish seeds; inodorous; taste extremely bitter.

The seeds, which constitute three-fourths by weight of the drug, are rejected in making preparations.

Contains the bitter cathartic principle *colocynthin;* also resin.

Used as a cathartic.

Dose of powder, 5 to 10 grains; Extract, 1 to 1½ grains; Compound Extract, 4 to 8 grains; Fluid Extract, 4 to 8 minims.

1218. Conium. HEMLOCK.

The full grown fruit of *Conium maculatum* (*Umbelliferæ*), gathered while yet green.

Europe, North America.

About ⅛ inch long, oval, gray-green; odor feeble but disagreeable; taste bitterish, slightly acrid. When triturated with potassa solution it gives off a pronounced, offensive odor.

Contains the poisonous volatile alkaloid *coniine*.

Sedative, narcotic.

Dose.—Abstract, 1 to 3 grains; Extract, ⅓ to 1 grain; Fluid Extract, 2 to 5 minims; Tincture, 15 to 60 minims.

Poisonous Effects.—Nausea, vomiting, disturbed vision, dizziness, numbness, paralysis asphyxia.

Antidotes.—Enforced strong muscular exercise; the administration of nux vomica or strychnine.

1219. Coriandrum CORIANDER.

The fruit of *Coriandrum sativum* (*Umbelliferæ*).

Southern Europe. Cultivated.

Globular, about ⅕ inch or less in diameter, slightly ridged, brownish-yellow; odor and taste peculiar, agreeable, aromatic.

Contains *volatile oil.*

Aromatic, stimulant, carminative. Chiefly employed for flavoring.

1220. Cubeba. CUBEB.

The unripe fruit of *Cubeba officinalis* (*Piperaceæ*).

Java. Cultivated.

Globular, of about the size of black pepper, dark grayish brown, wrinkled on the surface; interiorly light colored; odor strong, aromatic; taste pungent, aromatic, bitter.

Contains *volatile oil* and *resin*, and the crystallizable, inactive neutral principle called *cubebin*.

Stimulant, diuretic.

Dose.—Powder, 10 to 60 grains; Fluid Extract, 15 to 30 minims; Oleoresin, 5 to 10 grains; Tincture, ½ to 2 fluid drachms.

1221. **Foeniculum.** FENNEL.

The fruit of *Foeniculum vulgare* (*Umbelliferæ*).

Europe.   Cultivated.

About ¼ inch long, oblong, nearly cylindrical, slightly curved, greenish-brown, ribbed; odor and taste sweetish, aromatic, anise-like.

Contains *volatile oil.*

Stimulant, carminative.

1222. **Humulus.** HOPS.

The strobiles (or fruit cones) of *Humulus Lupulus* (*Urticaceæ*).

Cultivated.

About an inch long, yellowish-green cones; odor peculiar, aromatic; taste bitter, aromatic.

Constituents. *Lupulin* (1224) containing *volatile oil* and *resin;* hops also contain a little *tannin.*

Bitter, tonic, stomachic.

Dose of Tincture, 1 to 2 fluid drachms.

1223. **Juniperus.** JUNIPER BERRIES.

The ripe fruit of *Juniperus communis* (*Coniferæ*).

Northern countries.

Nearly globular, about ⅓ inch in diameter, dark purplish black with a bluish-gray bloom, fleshy, interiorly greenish brown; odor, aromatic, terebinthinate; taste, sweet, bitterish, pungent.

Contains *volatile oil, resin*, and sugar.

Stimulant and diuretic.

1224. **Kamala.** KAMALA.

The glands and hairs from the capsules of *Mallotus philippinensis* (*Euphorbiaceæ*).

India, Arabia.

A fine granular, brown-red powder, inodorous, tasteless, insoluble in water; imparting a deep red color to alcohol, ether, chloroform and alkaline solutions.

Contains nearly 80 per cent. of alcohol-soluble resin.   Yellow, needle-like crystals of *rottlerin* deposit from a concentrated ether solution.

Dose, as a *tænicide,* from 1 to 2 drachms.

1225. **Lupulinum.** LUPULIN.

A glandular powder separated from hops (1222).

Coarse, orange-brown or brownish-yellow, resinous, aromatic, bitter. Ether dissolves about three-fourths of it.

Contains volatile oil and resin.

Tonic, stomachic.

Dose.—Fluid Extract, 5 to 15 minims; Oleoresin, 2 to 4 grains; Tincture, ½ to 2 fluid drachms.

1226. Piper. BLACK PEPPER.

The unripe fruit of *Piper nigrum* (*Piperaceæ*).

India.

Globular, about ⅛ inch in diameter, much wrinkled, brownish-black or grayish-black, interiorly lighter, hollow; odor, peculiar, spicy; taste, spicy, hot.

Contains *volatile oil*, *resin*, and the feebly alkaloidal principle *piperine*.

Stimulant, carminative.

Dose of the Oleoresin ¼ to 1 grain.

1227. Vanilla. VANILLA BEAN.

The fruit of *Vanilla planifolia* (*Orchidaceæ*.)

Mexico; cultivated.

From 6 to 10 inches long, about ⅛ to ½ inch thick, much wrinkled, flexible, dark brown, glossy containing a blackish-brown oily-looking pulp. Odor, peculiar, heavy, very fragrant; taste, agreeably aromatic.

Contains the crystallizable fragrant principle *vanillin*, or vanillic acid. Used for flavoring.

1228. Amygdala. ALMOND.

Sweet almond and *bitter almond* are both seeds of *Amygdalus communis* (*Rosaceæ*); but sweet almond is obtained from the variety called *dulcis*, and the bitter almond from the variety called *amara*.

Both varieties of almond **contain** fixed oil ("sweet oil of almond"). Bitter almond contains also the crystallizable, bitter glucoside *amygdalin*, which decomposes when the almond is moistened, yielding *hydrocyanic acid* and *volatile oil of bitter almond*.

1229. Colchici Semen. COLCHICUM SEED.

The seed of *Colchicum autumnale* (*Melanthaceæ*).

Europe.

Subglobular, about $\frac{1}{12}$ inch in diameter, hard, tough, reddish-brown, interiorly whitish; inodorous; bitter, acrid.

Contains the alkaloid *colchicine*.

Alterative and diuretic, in gout.

Dose.—Fluid Extract, 2 to 5 minims; Tincture and Wine, 10 to 30 minims.

Poisonous Effects and **Antidotes.**—See Colchicum Root (1139).

1230. **Cydonium.** QUINCE SEED.

The seed of *Cydonia vulgaris* (*Rosaceæ*).

Cultivated.

About ¼ inch long, oval or oblong, compressed, dark brown, covered with a whitish, mucilaginous film, soluble in water.

Contains mucilage on the surface of the seed-coat.

1231. **Linum.** FLAXSEED.

The seed of *Linum usitatissimum* (*Linaceæ*).

Cultivated.

About ⅛ inch long, oblong, ovate, flattened, pointed at one end, brown, glossy, covered with a water-soluble vegetable mucilage.

Contains mucilage (on the surface of the seed-coat) and fixed oil.

1232. **Myristica.** NUTMEG.

The seed of *Myristica fragrans* (*Myristicaceæ*) deprived of its testa.

India, the Philippines, Banda Islands, West Indies, South America.

Oval, about 1 inch long, light brown, furrowed, interiorly pale brownish, with darker veins and greasy; strongly aromatic, pungent, bitter.

Contains *volatile oil* and *fixed oil.*

Stimulant, carminative.

1233. **Nux Vomica.** NUX VOMICA.

The seed of *Strychnos Nux-vomica* (*Loganiaceæ*).

East Indies.

Circular disks about 1 inch in diameter, ¼ inch thick, grayish or greenish-gray, with a silky lustre from soft hairs, hard, interiorly grayish-white, horny, tough, inodorous, intensely and persistently bitter.

Contains the extremely poisonous alkaloids *strychnine* and *brucine*.

Motor excitant; tonic.

Dose.—Abstract, ½ to 2 grs.; Extract, ¼ to 1 gr.; Fluid Extract, 1 to 5 minims; Tincture, 5 to 20 minims.

1234. **Physostigma.** CALABAR BEAN.

The seed of *Physostigma venenosum* (*Leguminosæ*).

Western Africa.

Roundish, oblong, about 1 inch long, ¾ inch broad and ½ inch thick, one long edge straight, the other convex, chocolate brown, with a black groove along the convex edge, interiorly white, fleshy; inodorous; taste, bean-like. The white color of the embryo turns pale yellow on being moistened with solution of potassa.

Active principle, the alkaloid *physostigmine,* also called "eserine;" it also contains another alkaloid called *calabarine.*

A motor depressant; extremely poisonous.

Dose.—Extract, 1-16 to ⅙ grain; Fluid Extract, 1 to 3 minims; Tincture, 15 to 30 minims.

Poisonous effects.—Extreme weakness, vomiting, feeble and slow pulse, collapse, death.

Antidotes.—After evacuation of the stomach and bowels, atropine is used hypodermatically.

1235 Sinapis. Mustard.

Two kinds of mustard are official—white and black.

White Mustard is the seed of *Sinapis alba (Cruciferæ).*

Globular, about 1-12 inch in diameter, pale brownish-yellow, hard; powder bright yellow; inodorous; pungent, acrid.

Black Mustard is the seed of *Sinapis nigra.*

Globular, about 1-24 inch in diameter, hard, blackish-brown; inodorous; pungent, acrid.

Both kinds of mustard are cultivated in Europe and America.

Constituents.—Mustard contains from 20 to 25 per cent. fixed oil. When moistened it emits a strong irritating odor, due to the "volatile oil of mustard" which is formed when water is added.

Mustard is a rubefacient.

1236. Stramonii Semen. Stramonium Seed.

The seed of *Datura Stramonium (Solanaceæ).*

North America and Europe.

Reniform, about ⅙ inch long, flattened, wrinkled, hard, brownish-black, interiorly whitish, oily; inodorous when whole, but emitting a disagreeable odor when bruised; taste bitter.

Contains the alkaloids *atropine* and *hyoscyamine;* also fixed oils.

Mydriatic anodyne.

Dose.—Extract, about ½ grain; Fluid Extract, 1 to 3 minims; Tincture, 8 to 30 minims.

It is also used *externally* in the form of ointment.

CHAPTER LXVIII.

MISCELLANEOUS CRUDE PLANT DRUGS.

Chondrus and Ergot.

1237. Chondrus. IRISH MOSS; CARRAGEEN.

Consists of *Chondrus crispus* and *C. mamillosus* (*Algæ*).

Tough, translucent, pale yellowish-white, branched; soft, slippery, carti-laginous-looking when put in water; boiled with from 20 to 30 parts of water, it forms, on cooling, a jelly of a mucilaginous taste and a distinct sea-weed odor.

Contains *pectin*

Demulcent.

1238. Ergota. ERGOT; SECALE CORNUTUM.

The sclerotium (compact spawn) or middle (second) stage of development of the fungus *Claviceps purpurea* (*Fungi*), which grows within the flower of the common rye, taking the place of the grain.

Southern Europe, especially Spain and Southern Russia.

Grain-like bodies about 1 to 2 inches long, $\frac{1}{8}$ to $\frac{1}{6}$ inch thick, nearly trian-gular, somewhat curved, marked lengthwise by three grooves, that on the inner side of the curve being most distinct; thickest about the middle, taper-ing gradually toward both ends, which are blunt; externally dark purplish, with a slight cloudy, bluish bloom; plump, firm, somewhat elastic but easily broken; fracture even, whitish toward the center but pinkish toward the cir-cumference; fissured when old; odor peculiar, heavy, disagreeable; taste, greasy, mawkish, nauseous.

When ergot is triturated with solution of potassium hydrate, a strong odor resembling that of herring brine (from trimethylamine) is developed.

Contains, according to Dragendorff and Podwissotzky, *scleretic acid, scleromucin* and *sclererythrin*, all of which are brown amorphous powders hav-ing the medicinal properties of the ergot.

Kobert produced the alkaloid *cornutine* from ergot; this, also, has the active properties of the drug in a high degree.

Ergot also contains 30 per cent. of fixed oil.

Uses.—Ergot is a motor excitant and causes contraction of the unstriped or involuntary muscular fibres, as of the uterus, sphincters and arterioles.

Dose.—Powder, 15 grains to 1 drachm; Extract 5 to 15 grains; Fluid Extract, 1 to 2 fluid drachms.

Extract-like Drugs.

1239. Aloe. ALOES; SOCOTRINE ALOES.

The inspissated juice of the leaves of *Aloe socotrina* (*Liliaceæ*). Eastern Africa and islands in the Indian Ocean.

Reddish-brown or orange-brown mosses, with a somewhat resinous, dull, opaque, conchoidal fracture; in quite thin fragments it is translucent, with a garnet-red or brownish-red color; the powder is yellowish-brown. Soluble in four times its weight of boiling water. It exhibits numerous crystals of aloin when mixed with alcohol and then examined under the microscope. Odor, saffron-like, fragrant, intensified when the aloes is breathed upon. Taste, extremely bitter.

Contains the bitter, purgative, resinous, neutral principle *aloin* and also a minute amount of volatile oil.

Properties.—Purgative; in smaller doses, laxative; in minute doses, a bitter, stomachic tonic.

Preparations and Doses.—Purified Aloes, in powder, as a tonic, 1 to 2 grs.; laxative, 2 to 5 grs.; purgative, 5 to 15 grs. Extract, ½ to 5 grs.; Tincture, 1 to 4 fluid drachms; Wine, about 4 fl. drs.

1240. Catechu. CATECHU; CUTCH.

An extract prepared from the wood of *Acacia Catechu* (*Leguminosæ*).

Pegu, and most parts of India and Burmah.

Dark-brown, brittle, irregular masses, somewhat glossy when freshly broken; soluble in water and in diluted alcohol; nearly inodorous; of strongly astringent, sweetish taste.

Contains *catechu-tannic acid* and *catechin.*

Astringent.

Dose.—Powder, 1 to 30 grains; Compound Tincture, 10 to 60 minims.

1241. Guarana. GUARANA.

A dried paste prepared from the seeds of *Paullinia sorbilis* (*Sapindaceæ*).

Brazil.

Cylindrical sticks, sometimes flattened, about 6 inches long and 1 inch in diameter, hard, externally dark-red brown, usually comparatively smooth, fracture uneven, coarsely granular, yet somewhat glossy, much lighter than the exterior. Odor, feeble, but peculiar, somewhat chocolate-like; taste, bitter, astringent. Guarana is partially soluble in alcohol, and also in water, the solutions being brown.

Constituents.—The alkaloid *guaranine* (probably identical with *theine*), and a large percentage of *tannin*.

Properties.—Guarana resembles tea and coffee in its action, being a cardiac stimulant.

Dose.—Powder, 10 to 60 grains; Fluid Extract, 10 to 60 minims.

1242. Kino. KINO.

The inspissated juice of *Pterocarpus Marsupium* (*Leguminosæ*). India.

Small, irregular, brittle, shining, dark, brown-red fragments, ruby-red and transparent in thin splinters. Colors the saliva deep-red; scarcely at all soluble in cold water, but almost entirely soluble in diluted alcohol; nearly insoluble in ether. Inodorous; very astringent, sweetish.

Contains *kino-tannic acid*.

Astringent.

Dose—Powder, 10 to 20 grains; Tincture, ½ to 2 fluid drachms.

1243. Lactucarium. LACTUCARIUM.

The hardened milk-juice of *Lactuca virosa* (*Compositæ*). Europe

In pieces showing the form of the vessel in which the juice was collected to harden. Often broken into irregular fragments. Exteriorly grayish-brown or dull reddish-brown, interiorly whitish or yellowish, waxy. Odor heavy, reminding somewhat of opium; taste, strongly bitter.

Partially soluble in alcohol and ether; yields a turbid mixture when triturated with water.

Contains bitter *lactucin*, which is its only important constituent.

Anodyne, soporific, hypnotic.

Dose.—8 to 30 grains; Fluid Extract, 5 to 30 minims; syrup, 2 to 3 fluid drachms.

1244. Opium. OPIUM.

The concreted, milky exudation obtained in Asia Minor by wounding the unripe capsules of *Papaver somniferum* (*Papaveraceæ*), and yielding in its normal soft condition not less than 9 per cent. of the alkaloid *morphine* when assayed by the official process.

Powdered Opium, which is opium dried at not over 85.° C. (185.° F.) and reduced to No. 50 powder, is required to yield not less than 12, nor more than 16, per cent. of *morphine*.

Crude opium, or whole opium, occurs in irregular sub-globular or flattened masses, with remains of poppy leaves and rumex seeds adhering to the sur-

face; moist enough to be soft or plastic, or so dry as not to flatten out when lying on a flat support. It is dark-brown, somewhat glossy when dry. The odor is peculiar, narcotic, nauseous; taste, bitter, disagreeable.

When dried the normal opium, or "lump opium," as imported, loses from ten to twenty per cent. of moisture.

When opium is dried at about 105° C. (221° F.) and then weighed and afterwards exhausted with cold water, the liquid water extracts being evaporated to dryness, the dry extract obtained should amount to from 55 to 60 per cent. of the weight of the dried opium taken.

Whole opium is used for making powdered opium and extract of opium, but all other opium preparations must be made from dry "powdered opium."

Active Principles.—The alkaloids *morphine* and *codeine* are the most valuable.

Properties.—Opium is a hypnotic. It is a powerful narcotic, often employed to relieve pain as well as to produce sleep, etc.

Dose.—Powders, about 1 grain; Extract, about ½ grain; Tinctures, about 10 minims; Vinegar, 5 to 10 minims; Wine, about 10 minims.

Compound Preparations.—Troches of Glycyrrhiza and Opium; Powder of Ipecac and Opium, or Dover's Powder, of which the adult dose is about 10 grains; Tincture of Ipecac and Opium, about 10 minims; Camphorated Tincture of Opium, of which the dose is about 2 to 4 fluid drachms.

A *Plaster of Opium* is also official.

Denarcotized Opium and **Deodorized** Tincture of Opium are contained in the Pharmacopœia. They are comparatively free from the alkaloid *narcotine*, which is considered an objectionable constituent, and from the nauseous odor.

Pills of Opium are also official.

All opium preparations of the United States Pharmacopœia, for internal use, are of 10 per cent. strength, with the sole exception of the Camphorated Tincture of Opium (" Paregoric ").

Poisonous Effects.—Drowsiness, profound lethargy, breathing labored, slow and stertorous; face dusky and swollen; pupils contracted; heart's action slow and feeble; total relaxation, coma, death from paralysis of the respiratory muscles.

Antidotes.—Prompt evacuation of the stomach by emetics or the stomach pump; then the patient should be compelled, if possible, to walk about, and the enforced exercise kept up; external stimulation, by rubbing, etc.; alcoholic stimulants, strong coffee; artificial respiration, if possible; and the administration of belladonna or atropine, or subcutaneous injections of atropine.

CHAPTER LXIX.

STARCHES, GUMS AND SUGARS.

1245. **Amylum.** STARCH. WHEAT STARCH.

The fecula or starch of the seed of *Triticum vulgare* (*Graminaceæ*),or wheat.

Manufactured in all countries from cultivated wheat.

Irregular, angular, soft, friable, white masses; inodorous and tasteless. Insoluble in cold water, alcohol and ether.

1246. **Maranta.** ARROW-ROOT.

The fecula separated from the rhizome of *Maranta arundinacea* (*Cannaceæ*).

Bermudas, West Indies, Central and South America.

Used for preparing foods for infants and invalids.

1247. **Acacia.** GUM ARABIC.

The dried gummy exudation from *Acacia Verek* and other species of *Acacia* (*Leguminosæ*).

Africa.

Irregularly-shaped fragments or tears, opaque from numerous fissues, glass-like in the fracture, transparent in thin pieces; nearly inodorous; taste mucilaginous, insipid. Entirely soluble in water; insoluble in alcohol.

Used in powder as an emulsifying agent and as an excipient; also in the form of *mucilage* for the same and other similar purposes, and as a demulcent.

1248. **Tragacantha.** TRAGACANTH.

The dried gummy exudation from *Astragalus gummifer* and other species of *Astragalus* (*Leguminosæ*).

Western Asia.

Irregular, contorted bands, whitish, translucent, horn-like, tough, swelling in water to a gelatinous, sticky mass.

Used as an excipient either in powder or in the form of *mucilage of tragacanth*.

1249. **Saccharum.** SUGAR.

The refined sugar ($C_{12}H_{22}O_{11}$) of *Saccharum officinarum* (*Graminaceæ*).

The Pharmacopœia defines sugar as cane-sugar, only; but most of the white sugar now consists of beet-root sugar.

Sugar is soluble in about half its weight of water at $15°$ C.; it is also soluble in 175 parts of alcohol at $15°$ C., but insoluble in ether.

1250. Saccharum Lactis. MILK SUGAR.

This variety of sugar ($C_{12}H_{22}O_{11}.H_2O$) is obtained from the whey of cow's milk.

Hard, crystalline, white, inodorous, sweetish, soluble in 7 times its weight of water at 15°C.

Used as a diluent in powders, triturations, and in various tablets, granules, etc.

1251. Manna. MANNA.

The concreted saccharine exudation from *Fraxinus Ornus* (*Oleaceæ*).

Southern Europe.

Flattish, trough-shaped or three-edged pieces, friable, yellowish-white, porous crystalline; odor peculiar, sweetish; taste sweet, leaving a slightly bitter, acrid after-taste. Water-soluble, and soluble also in 15 parts of boiling alcohol.

Consists mainly of *mannit* and *glucose*.

Used as a mild laxative.

1252. Mel. HONEY.

A saccharine secretion deposited by the bee, *Apis mellifica* (*Insecta*).

Syrupy, or semi-fluid and granular, pale yellow or brownish-yellow, of a peculiar sweetish odor; very sweet, afterwards faintly acrid taste. When heated, skimmed and strained, it is called *clarified honey*, which is used in the preparation of confection of rose, honey of rose, and in mass of carbonate of iron.

CHAPTER LXX.

GUM-RESINS, RESINS, AND BALSAMS.

1253. Ammoniacum. AMMONIAC.

A gum-resin (1123) obtained from *Dorema Ammoniacum* (*Umbelliferæ*).

Persia, Turkestan.

Roundish tears of various sizes rarely exceeding an inch in diameter, pale brownish-yellow exteriorly, white interiorly, brittle only when cold, fracture

waxy and conchoidal; odor peculiar; taste bitter, acrid, disagreeable. Yields a milk-white emulsion when triturated with water.

Contains *volatile oil*, resin and gum.

Antispasmodic and blennorhetic. Externally a stimulant and rubefacient.

Preparations.—Mixture of Ammoniac, and for external use the Ammoniac Plaster with or without mercury.

1254. Asafœtida. ASAFETIDA.

A gum-resin obtained from the root of *Ferula Narthex* and *F. Scorodosma (Umbelliferæ)*.

Persia, and other countries on the Arabian Sea.

Tears, exteriorly brown, interiorly white, or masses composed of such tears imbedded in a yellowish-brown soft or hard mass. When hard the tears break with a conchoidal waxy fracture, the milk-white color of the surface of the fracture changes gradually on exposure to the air to pink and brown. Odor strong garlicky, offensive; taste bitter, acrid, garlicky. When triturated with water it yields a nearly milk-white emulsion. At least 60 per cent. of the asafetida should be dissolved by alcohol.

Contains *volatile oil*, resin and gum.

Used as a nervine and antispasmodic, and also externally as a stimulant application in the form of plaster.

Preparations.—Mixture (dose, 4 fluid drachms), Tincture (dose, 30 to 60 minims), Pills of Asafetida, Pills of Aloes and Asafetida, Compound Pills of Galbanum. Asafetida Plaster.

1255. Galbanum. GALBANUM.

The gum-resinous exudation from *Ferula galbaniflua*, and probably from other related plants (*Umbelliferæ*).

Persia.

Masses consisting of small agglutinated tears, exteriorly yellowish-brown, interiorly whitish, fracture waxy; odor peculiar, disagreeable; taste bitter, acrid.

Contains *volatile oil*, resin and gum.

Stimulant, blennorrhetic, externally stimulant.

Preparations.—Galbanum Plaster, Compound Pills of Galbanum, and in Asafetida Plaster.

1256. Cambogia. GAMBOGE.

A gum-resin from *Garcinia Hanburii (Guttiferæ)*.

Siam.

Cylindrical pieces, from ¾ to 2 inches in diameter, brownish orange-yellow; fracture smooth, waxy; powder bright yellow; inodorous; acrid. Triturated with water it yields a yellow emulsion.

Contains resinous gambogic acid and gum.

It is a powerful hydragogue cathartic (dose, 1 to 5 grains) and is contained in Compound Cathartic Pills.

1257. Myrrha. MYRRH.

A gum-resin from *Balsamodendron Myrrha* (*Burseraceæ*).

Eastern Africa and southwestern Arabia.

Irregular pieces, brownish yellow or reddish-brown, wax-like fracture, translucent with a wine-red color when in thin splinters or pieces; yields a light brownish-yellow powder; odor balsamic, peculiar; taste bitter, acrid. Triturated with water it forms a brownish-yellow emulsion.

Contains *volatile oil*, resin and gum.

It is tonic, stimulant, blennorrhetic.

Slightly astringent.

Dose.—Powder, 8 to 30 grains; Tincture, 15 to 60 minims.

It is contained in Compound Iron Mixture, Pills of Aloes and Myrrh, Com. Iron Pills, Com. Pills of Galbanum, Tinct. or Aloes and Myrrh.

1258. Resina. RESIN, COLOPHONY.

The resin left after distilling off the volatile oil from turpentine (1267).

The United States. Large quantities are produced in North Carolina.

Transparent, amber-colored, hard, brittle, with a glossy fracture, odor feeble terebinthinate, taste resinous. Melts at about 135°C. (275°F.) Soluble in alcohol, ether, volatile oils, and fixed oils; insoluble in water.

Consists of abietic anhydride.

Used as an ingredient in plasters, cerates, and ointments.

1259. Guaiaci Resina. GUAIAC RESIN.

The resin of the heart wood of *Guaiacum officinale* (*Zygophyllaceæ*).

West Indies and South America.

Dark, greenish-brown, in large masses, nearly black, in thin splinters, translucent, brittle, fracture glassy; fusible, emitting an aromatic odor when melted; somewhat acrid to the taste. The powder is light-grayish, but becomes green on exposure to the air.

Properties.—Diaphoretic, diuretic, alterative, stimulant.

Dose.—Powder, 8 to 15 grains; Tincture and Ammoniated Tincture, 30 to 60 minims.

1260. Mastiche. MASTIC.

The hardened resinous exudation from *Pistacia Lentiscus* (*Terebinthaceæ*).

Mediterranean countries.

Globular tears, smaller than a pea, pale yellow, transparent, brittle, yielding a white powder; odor and taste resinous. Soluble in absolute alcohol.

Used in pills of aloes and Mastic.

1261. Pix Burgundica. BURGUNDY PITCH.

Prepared resinous exudation from *Abies excelsa* (*Coniferæ*). Southern Europe.

Hard at ordinary temperature, but very soft, running, when warmer, opaque or translucent. Brittle when cold, fracture glossy; yellowish brown, somewhat aromatic.

Used as an ingredient in Burgundy pitch plaster and in pitch plaster with cantharides.

1262. Scammonium. SCAMMONY.

A hardened, resinous exudation, from the root of *Convolvulus Scammonia* (*Convolvulaceæ*).

Minor Asia. Smyrna.

Irregular pieces, or circular cakes, greenish gray, porous, fracture angular; odor peculiar, somewhat cheese-like; taste slightly acrid.

Consists mainly of the resin called *scammonin.* Cathartic.

Dose.—Powder, 5 to 15 grains; the official Resin of Scammony is purified Scammony; dose, 3 to 10 grains.

1263. Benzoinum. BENZOIN.

balsamic resin from *Styrax Benzoin* (*Styraceæ*).

Siam, Sumatra.

Resinous masses of a grayish-brown color, the exterior being darker when longer exposed, interiorly mottled, large tears or "almonds" of pure, opaque resin being imbedded in a mass of translucent, yellowish-brown resin, the tears being milk-white in the fracture; odor agreeable, balsamic; taste faintly but gratefully aromatic. Benzoin is almost entirely solution in solution of potassa, and also in 5 parts of warm alcohol. It emits vapors of benzoic acid when heated.

Contains from 15 to 20 per cent. of *benzoic acid* and a minute quantity of *volatile oil.*

Used in external applications as a cosmetic, as a preservative of fats, and as an aromatizer.

Preparations.—Benzoinated Lard, Tincture of Benzoin and Compound Tincture of Benzoin.

1264. Balsamum Peruvianum. BALSAM OF PERU.

A thick liquid balsam obtained from *Myroxylon Pereiræ* (*Leguminosæ*).

Central America.

Brownish-black, lighter or reddish-brown and transparent in thin layers. Odor agreeable, balsamic, reminding of a combination of vanilla and benzoin. Taste warm, bitterish, finally acrid. Wholly soluble in 5 parts of alcohol.

Contains about 6 per cent. *cinnamic acid.* About 30 per cent. consists of resins; and 60 per cent. of benzyl cinnamate (cinnamein), which is an oily liquid.

Uses.—Externally it is used as a cure for the itch, and it is added to ointments as a preservative. Internally it is expectorant and blennorrhetic.

1265. Balsamum Tolutanum. BALSAM OF TOLU.

A semi-solid or solid balsamic resin obtained from *Myroxylon toluifera* (*Leguminosæ*).

Venezuela and New Granada.

Yellowish-brown, or brownish-yellow, transparent in thin layers, brittle when cold; soft at ordinary room temperatures, running when warmed; odor agreeable, balsamic; taste feeble but pleasantly aromatic. Entirely soluble in alcohol.

Contains *cinnamic acid, volatile oil* and minute amounts of other aromatic bodies.

Used as a blennorrhetic, but mainly as a pleasant addition to cough mixtures, etc.

Preparations.—Tincture and Syrup.

1266. Styrax. STORAX.

A balsam prepared from the inner bark of *Liquidambar orientalis* (*Hamamelaceæ*).

Asia Minor.

Tenacious, semi fluid, sticky, gray, opaque, transparent in thin layers. Odor agreeable, balsamic; taste balsamic. Entirely soluble in an equal weight of warm alcohol.

Contains *styrol, cinnamic acid, styracin,* and other cinnamic ethers, resin, etc.

Used in Compound Tincture of Benzoin.

1267. Terebinthina. Turpentine.

The concreted oleoresin from *Pinus australis* and other species of *Pinus* (*Coniferæ*).

North Carolina and other southeastern portions of the United States.

Yellowish, tough masses, brittle in the cold, granular interiorly; odor and taste terebinthinate.

Consists of volatile oil and resin.

Used as a stimulant ingredient in some ointments and plasters.

1268. Terebinthina Canadensis. Canada Turpentine. [Balsam of Fir.]

A thick liquid oleoresin from *Abies balsamea* (*Coniferæ*).

Pale yellowish, or faintly greenish, transparent; odor terebinthinate; taste bitterish, slightly acrid. Entirely soluble in ether, chloroform, benzol.

1269. Pix Liquida. Tar.

An empyreumatic oleoresin ["pyroleum"] obtained by destructive distillation of the wood of *Pinus palustris* and of other species of *Pinus* (*Coniferæ*).

North Carolina.   Produced also in many other localities in Europe and America.

Thick, viscid, blackish-brown, transparent in thin layers, granular and opaque when old; heavier than water; reaction acid; odor empyreumatic terebinthinate; taste sharp, and smoky. Soluble in alcohol.

Contains oil of turpentine, acetic acid, creasote, phenol, pyrocatechin, resin, etc. The granular appearance of old tar is due to crystals of pyro-catechin, which is soluble in water as well as alcohol, and pungent.

Uses —Stimulant, blennorrhetic. Also used externally in skin affections.

Preparations.—Syrup and Ointment.

1270. Copaiba. "Balsam of Copaiba."

The oleoresin [not a "balsam"] of *Copaifera Langsdorffii* and other species of *Copaifera* (*Leguminosæ*).

Brazil.

A pale yellowish or brownish-yellow transparent or translucent, syrupy liquid; odor peculiar, aromatic, nauseous; taste nauseous, persistently bitter, acrid. Readily soluble in absolute alcohol.

Contains *volatile oil* and *resin*.

Properties.—Expectorant, blennorrhetic, diuretic diaphoretic.

Dose.—10 to 60 minims.

CHAPTER LXXI.

FATS AND FIXED OILS.

1271. Adeps. Lard.

Hog's lard, recently rendered and refined.

A soft, white, free from rancidity, of bland taste. Melts at 35° C. (95° F.)

Used in preparing ointments and cerates.

1272. Cera. Wax.

A peculiar solid fat deposited by the bee.

Cera Flava is the natural, or yellow, wax.

Cera Alba is white wax prepared by bleaching the yellow wax.

Wax melts at about 64° C. (147° F.); is soluble in ether and chloroform.

Used in cerates, ointments and plasters.

1273. Cetaceum. Spermaceti.

A peculiar fat from *Physeter macrocephalus*, the sperm whale.

Perfectly white, somewhat translucent in thin layers, unctuous, scaly, crystalline, inodorous, of a bland taste. Melts near 50° C. (122° F.), and congeals at about 45° C. (113° F.)

Used in cerates and ointments.

1274. Sevum. Suet.

Recently rendered mutton-suet, free from rancidity.

White, nearly inodorous, bland. Melts between 45° and 50° C. (113° and 122° F.).

Used in mercurial ointment.

1275. Oleum Adipis. Lard Oil.

The fixed oil expressed from lard at a low temperature.

Colorless or pale yellowish, nearly inodorous, bland, free from rancidity.

1276. Oleum Amygdalæ Expressum. Expressed oil of Almond. Sweet oil of Almond.

The fixed oil expressed from the Bitter and Sweet Almond.

Nearly colorless, or of a pale straw color, of a mild nutty odor and taste.

Used in "cold cream" and phosphorated oil.

1277. Oleum Gossypii Seminis. Cotton Seed Oil.

From the seed of *Gossypium herbaceum* (*Malvaceæ*), and other species of *Gossypium*.

Pale yellow, inodorous, bland.

1278. Oleum Lini. Flaxseed Oil. Linseed Oil.

Expressed from flaxseed without the aid of heat (1231).

A yellowish or light yellowish-brown drying oil of a mild peculiar odor and bland taste.

1279. Oleum Morrhuæ. Cod Liver Oil.

From the fresh livers of *Gadus Morrhua* and other species of *Gadus* (Pisces).

Northeastern coasts of the United States, Newfoundland, Norway.

Colorless or pale yellow, thin, of fishy odor and a bland, slightly fishy taste.

1280. Oleum Olivæ. Olive Oil. Sweet Oil.

From the ripe fruit of the Olive, *Olea europæa* (*Oleaceæ*).

France, Italy, Spain.

Pale yellow; of a faint agreeable nutty odor and taste, bland.

1281. Oleum Ricini. Castor Oil.

From the seed of *Ricinus communis* (*Euphorbiaceæ*).

The United States. Italy.

Colorless, or nearly so, with a pale yellowish tint, viscid, odor feeble but nauseating; taste bland but nauseating, finally slightly acrid. Soluble in an equal weight of alcohol and miscible with absolute alcohol in all proportions

1282. Oleum Sesami. Sesamum Oil. Benné Oil.

From the seed of *Sesamum indicum* (*Pedaliaceæ*).

Light yellow, inodorous or nearly so, bland.

1283. Oleum Theobromæ. Oil of Theobroma. Butter of Cacao.

A solid fat from the seed of *Theobroma Cacao* (*Sterculiaceæ*).

Mexico.

Yellowish-white; odor faint but rather agreeable; taste bland, reminding somewhat of chocolate. Melts at 30° to 35° C. (86° to 95° F.).

Used for making suppositories.

1284. Oleum Tiglii. Croton Oil.

From the seed of *Croton Tiglium* (*Euphorbiaceæ*).

India.

Yellow or brownish-yellow, slightly fluorescent; odor feeble, fatty; taste first mild, oily, then acrid, burning. Applied to the skin it vesicates. Incompletely soluble in alcohol, quite soluble in ether and chloroform.

Used sometimes internally as a drastic cathartic. Externally as an irritant and suppurant.

Dose one-fourth to two drops, in olive oil, or otherwise well diluted or distributed.

CHAPTER LXXII.

VOLATILE OILS AND CAMPHORS.

1285. Oleum Amygdalæ Amaræ. OIL OF BITTER ALMOND.

A volatile oil produced in bitter almond by maceration with water and obtained by subsequent distillation.

Colorless or pale yellow; odor peculiar, hydrocyanic acid-like; taste bitter, burning. Scarcely soluble in alcohol.

1286. Oleum Anisi. OIL OF ANISE.

From Anise (1212).

Colorless or pale yellow, having the peculiar odor of anise, and a sweetish, aromatic, burning taste. Soluble in an equal weight of alcohol. Solidifies at from 10° to 15° C. (50° to 59° F.).

Used as a stimulant carminative, and as a flavoring agent.

Oil of Star Anise resembles the true Oil of Anise but does not congeal until at about 2° C. (35.°6 F.).

1287. Oleum Aurantii Corticis. OIL OF ORANGE PEEL.

Expressed from the peel of fresh sweet orange.

Pale yellowish, of the characteristic odor of sweet orange; an aromatic, burning; somewhat bitter taste.

Used for flavoring.

1288. Oleum Aurantii Florum. OIL OF ORANGE FLOWERS. OIL OF NEROLI.

Yellowish or brownish-yellow, of the fragrant odor of orange flowers; taste aromatic, bitterish, burning.

Used in perfumery.

1289. Oleum Bergamii. OIL OF BERGAMOT.

Expressed from the rind of the fruit of *Citrus Bergamia* (*Aurantiaceæ*).

Pale greenish; odor very fragrant.

Used in perfumery.

1290. Oleum Cari. OIL OF CARAWAY.

Distilled from Caraway (1215).

Colorless or pale yellowish, of the peculiar odor of caraway, and a characteristic spicy taste.

Used as a stimulant carminative and for flavoring.

1291. Oleum Caryophylli. Oil of Cloves.
Distilled from Cloves (1191)

Light brown, or brownish-yellow, of a strong spicy odor of cloves, and burning taste. Very soluble in alcohol.

1292. Oleum Cinnamomi. Oil of Cinnamon.
Pale yellowish-brown, of the strong characteristic aromatic odor of cinnamon, and a spicy, burning taste (1170).

Used for flavoring.

1293. Oleum Copaibæ. Oil of Copaiba.
The volatile oil distilled from Copaiba.

Pale yellowish, or nearly colorless, of the odor of copaiba, and a pungent, bitterish taste.

Used for the same purposes as copaiba (1270).

Dose.—5 to 15 minims.

1294. Oleum Coriandri. Oil of Coriander.
Distilled from Coriander (1219).

Colorless or pale yellowish, aromatic, spicy.

Used for flavoring.

1295. Oleum Cubebæ. Oil of Cubeb.
Distilled from Cubeb (1220).

Pale greenish, or greenish-yellow, of the odor of cubeb, and a hot, camphoraceous taste.

Used for the same purposes as Cubeb (1220).

Dose.—5 to 15 minims.

1296. Oleum Eucalypti. Oil of Eucalyptus.
Distilled from fresh Eucalyptus leaves (1202).

Colorless or pale yellowish, of the strong, peculiar, camphoraceous odor of Eucalyptus, and a pungent, cooling taste.

Used as an antiseptic.

1297. Oleum Fœniculi. Oil of Fennel.
Distilled from Fennel (1221).

Colorless or pale yellow, sweetish, aromatic, spicy.

Used as a carminative and flavoring agent.

1298. Oleum Gaultheriæ. Oil of Wintergreen.
Distilled from Gaultheria.

Colorless or pale yellow, or reddish-yellow, of a peculiar strong odor, and a sweetish, warm, aromatic taste. Consists mainly of methyl salicylate.

Used as an antiseptic and for flavoring.

1299. Oleum Juniperi. OIL OF JUNIPER.

Distilled from Juniper berries (1223).

Colorless, or pale yellowish, of the characteristic odor of Juniper, and a warm, aromatic, sweetish, terebinthinate taste.

A constituent of gin.

1300. Oleum Lavandulæ. OIL OF LAVENDER.

Distilled from the flowering tops or herb of Lavender (1193). [Called in the trade "Oil of Garden Lavender."]

Colorless or pale yellowish, of strong but coarse lavender odor, and a pungent, bitterish taste.

Used in liniments.

1301. Oleum Lavandulæ Florum. OIL OF LAVENDER FLOWERS.

Distilled from fresh Lavender flowers (1193).

Colorless or pale yellowish, of a superior fragrant lavender odor, and a pungent, bitterish taste.

Used for flavoring and in perfumery.

1302. Oleum Limonis. OIL OF LEMON.

Expressed from fresh lemon peel.

Pale yellow, of the aromatic fragrance of lemon, and an agreeable, aromatic, pungent taste.

Used for flavoring.

1303. Oleum Menthæ Piperitæ. OIL OF PEPPERMINT.

Distilled from Peppermint (1187).

Colorless or pale yellowish, having a strong odor of peppermint, and a burning, aromatic taste, producing in the mouth a cooling sensation, when air is inhaled

Its most important constituent is *menthol*.

Used as a carminative, and for flavoring.

1304. Oleum Pimentæ. OIL OF ALLSPICE.

Distilled from Pimenta.

Pale brownish-yellow, of the strong spicy odor, and taste of allspice.

Used for flavoring.

1305. Oleum Rosæ. OIL OF ROSE.

Distilled from the fresh flowers of *Rosa damascena* (*Rosaceæ*). France and other Mediterranean countries.

Very pale yellowish, of a powerful rose odor, and a sweetish aromatic taste. Solidifies at about 10° C. (50° F)

Used for flavoring, and in perfumery.

1306. Oleum Rosmarini. OIL OF ROSEMARY.

Distilled from Rosemary leaves (1206).

Colorless or pale yellowish, agreeably aromatic, pungent, camphoraceous.

Used in liniments, and for flavoring, and is an important constituent of Cologne water

1307. Oleum Sabinæ. OIL OF SAVIN.

Distilled from *Juniperus Sabina* (*Coniferæ*).

Colorless, or pale yellowish, of the peculiar strong, somewhat terebinthinate, odor of Savin, and a burning, bitterish, camphoraceous taste.

Stimulant, irritant.

Dose.—About 5 drops.

1308. Oleum Sassafras. OIL OF SASSAFRAS.

Distilled from Sassafras (1179).

Colorless, or pale yellowish, of the characteristic odor of Sassafras, and a warm aromatic taste.

Used as a carminative and for flavoring.

1309. Oleum Sinapis Volatile. VOLATILE OIL OF MUSTARD.

A volatile oil produced by the maceration of black mustard with water, and obtained by subsequent distillation (1235).

Colorless, or pale yellowish, extremely offensive, pungent, acrid.

Used as a rubefacient in liniments.

1310. Oleum Terebinthinæ. OIL OF TURPENTINE.

The volatile oil distilled from Turpentine (1267).

Colorless, thin, of a characteristic odor, and burning taste.

Used in liniments. It is also stimulant, diuretic, anthelmintic and purgative.

Dose.—As a stimulant, 5 to 15 minims.

1311. Camphora. CAMPHOR.

A stearopten ($C_{10}H_{16}O$) derived from *Cinnamomum Camphora* (*Lauraceæ*).

China, Japan, Formosa.

White, translucent, in thin fragments perfectly transparent, tough, crystalline, readily pulverizable when moistened with alcohol, ether or chloroform. Odor characteristic, penetrating; taste pungent. Melts at 175° C. (347° F.), boils at 205° C. (401° F.), and sublimes without residue. Is readily ignited,

and burns with a smoky flame. Entirely and readily soluble in alcohol, ether, chloroform, volatile oils, fixed oils.

Properties.—Stimulant of brain and circulation. Prophylactic and antiseptic. Diaphoretic.

Dose.—1 to 5 grains.

Preparations.—Camphor Water, Spirit of Camphor, Cerate and Liniment.

1312. **Menthol.** MENTHOL.

The stearopten from oil of peppermint.

In small white or transparent slender, prismatic crystals having the composition $C_{10}H_{20}O$. Odor of peppermint; taste pungent, afterwards cooling. Readily soluble in alcohol and ether.

Properties.—Stimulant, antiseptic, anti-neuralgic.

CHAPTER LXXIII.

ANIMAL DRUGS.

(NOT ELSEWHERE MENTIONED.)

1313. **Cantharis.** CANTHARIDES.

Spanish Flies.

The entire insect *Cantharis vesicatoria* (*Coleoptera*).

Spain, Southern Russia, and other localities in southern Europe.

About an inch long, $\frac{1}{4}$ inch broad; hard shell, shining copper green; odor peculiar, nauseous; taste nauseous, burning. The powder is grayish-brown, with green, shining particles. Applied to the skin, it vesicates.

Contains the vesicant principle, *cantharidin*.

Uses.—Stimulant, diuretic ; externally rubefacient, vesicant

Dose of the Tincture, 5 to 15 minims.

The preparations for external use are two Cerates, Collodion, Liniment, and Pitch Plaster with Cantharides.

1314. **Fel Bovis.** OX-GALL.

The fresh gall of beef cattle. *Bos Taurus* (*Mammalia*).

Brownish green or dark green, of a peculiar nauseous odor and an intensely bitter taste.

In a purified state, evaporated down to an extract-like soft solid, it is still sometimes used as a purgative.

Dose, 5 to 8 grains.

1315. Moschus. MUSK.

The dried secretion from the preputial follicles of *Moschus Moschiferus* (*Mammalia*).

Dark reddish-brown masses or a crummy granular coarse powder, of a peculiar and very strong, penetrating, persistent odor, and bitterish taste.

Contains resinous matter, etc

Uses.—Stimulant, antispasmodic. Also used in perfumery.

Dose of musk, 5 to 10 grains ; Tincture, 15 to 80 minims.

1316. Pepsinum. *Pepsin.*

Pepsin is the digestive principle of the gastric juice, obtained from the mucous membrane of the stomach of the hog.

The Saccharated Pepsin of the Pharmacopœia is pepsin mixed with powdered milk sugar. It is white, and of slight, but not disagreeable odor and taste.

Pepsin digests albumin, and the Pharmacopœia requires that 1 part of Saccharated Pepsin shall digest at least 50 times its weight of hard-boiled white of egg within six hours, at 39°C. (102°F.), when mixed with 500 parts of water acidulated with 7.5 parts of hydrochloric acid.

Used in dyspepsia and apepsia.

CHAPTER LXXIV.

THERAPEUTIC CLASSIFICATION OF MEDICINES.

1317. Medicines are classified according to their therapeutic effects and mode of use.

Thus they may first be divided into two great groups: 1, **Systemic Medicines**, which act on the whole body through their effect upon its organs and their functions; and 2, **Topical Medicines**, having local or limited effects.

1318. The systemic medicines may be divided into three classes: 1, Those acting upon the digestion, nutrition and the

temperature of the body; 2, Those acting upon the several organs, as upon the nervous system, the circulatory organs, sexual organs and the alimentary canal; and 3, Those affecting the secretions.

1319. Systemic Medicines of the first class are: digestants, tonics, alteratives and antipyretics.

Those of the second class are: A, hypnotics, mydriatics, anodynes, anæsthetics, antispasmodics, motor-excitants and motor-depressants; B, stimulants and sedatives influencing the circulation; C, aphrodisiacs, anaphrodisiacs, oxytocics, uterine sedatives, and emmenagogues; D, emetics, gastric sedatives, carminatives, cathartics and anthelmintics.

Systemic Medicines of the third class are: Diuretics, diaphoretics, expectorants, astringents and antacids.

1320. Topical Medicines are divided into: antiseptics, irritants, demulcents, emollients and protectives.

1321. **Digestants** are medicines which aid digestion.

Ex. *Pepsin, pancreatin, papain, malt extract.*

1322. **Tonics** are remedies which restore strength and energy to the body or its parts, or increase its vigor. The tonics are divided into vegetable tonics, or bitters, and mineral tonics.

Bitter Tonics are numerous. Among them are *gentian quassia, calumba, serpentaria, anthemis, bitter orange peel, absinthium, cinchona, salix, hydrastis,* etc.

Mineral Tonics include the preparations of *iron* and *phosphorus*, and the *mineral acids.*

1323. **Alteratives** do not act upon particular organs, but establish conditions favorable to the re-establishment of the healthy functions of the system.

Among the most commonly employed alteratives are the preparations of *mercury* and *gold, iodine* and *iodides; arsenic; phosphates* and *hypophosphites; cod-liver oil; sarsaparilla, guaiac, stillingia* and *colchicum.*

1324. Antipyretics reduce the temperature of the body when abnormally high, as in fevers.

Ex.—*Antipyrin, acetanilid, quinine, salicin, salicylates, salol, acetphenetidin, resorcin, hydroquinone, chinoline, thalline* and *kairine*.

1325. Hypnotics are remedies inducing sleep. They may be *narcotics*, which stupefy, or *anodynes*, which lessen excitement and relieve pain.

The principal hypnotics are *opium, morphine* and *codeine, hyoscyamus, cannabis indica, bromides, chloral, paraldehyd, hypnone, urethan*.

1326. Mydriatic Anodynes are used to relieve pain (as analgesics and antispasmodics); they dilate the pupil, and in large dose produce restless delirium instead of sleep.

Belladonna, hyoscyamus, stramonium, erythroxylon and *antipyrin* are *mydriatic anodynes*.

1327. Anæsthetics are substances which, when their vapor is inhaled, produce insensibility to pain or to touch, and unconsciousness.

The principal anæsthetics are *ether, chloroform, nitrogen monoxide, methylene bichloride* and *ethyl bromide*.

1328. Antispasmodics are medicines which relieve or prevent spasmodic pain or the spasmodic action of the muscles.

Among them are *camphor, valerian, asafetida, musk, cypripedium, ether*.

1329. Motor-Excitants are medicines which excite muscular action by their stimulant effect upon the reflex centers of the spinal cord.

The most important are *nux vomica, strychnine* and *ignatia*.

1330. Motor-Depressants are medicines producing effects the opposite of those of the motor-excitants (1329). They depress the functions of the spinal cord and lessen muscular activity.

Hydrocyanic acid, chloral, bromides, physostigma, gelsemium, conium, lobelia and *tobacco* are motor-depressants.

1331. Cardiac and **Arterial Stimulants** are medicines which increase the action of the heart and the force of the circulation of blood.

Among the stimulants of the organs of circulation are: *Alcohol, ether, ammonia, atropine, digitalis, strophanthus, strychnine, caffeine.*

1332. Cardiac and **Arterial Sedatives** are medicines which diminish the force and frequency of the heart contractions, and depress circulation. They are the opposite of the cardiac and arterial stimulants (1331).

Aconite, veratrum viride, gelsemium, veratrine, and *antimony* preparations are sedatives of this kind.

1333. Aphrodisiacs are remedies which excite the functions of the genital organs when morbidly depressed.

Anaphrodisiacs are the opposite of aphrodisiacs, depressing the sexual functions when excited.

1334. Oxytocics are medicines which increase the contractile power of the uterus.

Ergot and *cotton root bark* are oxytocics.

Uterine Sedatives are medicines which diminish or depress uterine contractions.

Emmenagogues increase or re-establish the menstrual flow when suppressed from causes other than pregnancy or age.

1335. Emetics are medicines which induce vomiting.

The most important emetics are *ipecac, apomorphine* and *mustard,* copious draughts of *warm water, tartar emetic, zinc sulphate, copper sulphate, alum* and *subsulphate of mercury.*

1336. Carminatives are medicines which aid the expulsion of gases from the stomach and intestines.

Drugs containing volatile oils, and the *volatile oils* themselves, are used for this purpose, as *anise, caraway, fennel, asafetida, oil of turpentine, eucalyptus,* etc.

1337. Cathartics are medicines which cause the evacuation of the bowels, either by increasing the peristaltic motion of the intestines, or by augmenting the intestinal secretions.

Powerful cathartics are called *drastic purgatives*, and irritant cathartics producing watery stools by causing a copious increase of the secretions are called *hydragogue cathartics*, while medicines which relieve the bowels of their contents without irritation or purgation are called *laxatives*.

Saline cathartics produce liquid stools not only by increasing peristalsis, but also by causing exosmosis of water from the blood vessels.

Among the *laxatives* are *castor oil, tamarinds, manna, frangula, rhamnus purshiana* and *sulphur*.

Among the *simple purgatives* are *rhubarb, aloes, senna, calomel* and *blue mass*.

The *saline cathartics* include the *magnesium salts* and *rochelle salt*.

The *drastic purgatives* include *jalap, scammony, gamboge, elaterin* and *elaterium, croton oil, podophyllum, etc.*

1338. **Anthelmintics** are medecines employed to kill or expel intestinal worms. Those that kill the worms are called *vermicides;* medicines which expel the worms are caled *vermifuges.*

Among the anthelmintics are *aspidium, brayera, chenopodium, granatum, kamala, pepo, santonica* and *santonin, spigelia,* and *oil of turpentine*.

1339. **Diuretics** are medicines which increase the flow of urine. They may be grouped into alkaline, hydragogue and alterative diuretics.

Acetate, nitrate and *bicarbonate of potassium, lithium citrate* and *chloride,* and *sodium acetate* are *alkaline diuretics*.

Squill, digitalis, caffeine, scoparius, and *spirit of nitrous ether* are *hydrogogue diuretics*.

Buchu, pareira, uva ursi, chimaphila, juniqer, oil of turpentine, oil of santal, copaiba, cubeb, and matico are *alterative diuretics*.

1340. **Diaphoretics** are medicines which increase or cause perspiration. They are grouped into nauseating, sedative, saline and special diaphoretics. When they are so powerful as to bring on profuse sweating they are called *sudorifics*.

Nauseant diaphoretics are represented by ipecac and Dover's powder. *Sedative diaphoretics* by *antimony* preparations, *aconite* and *veratrum vivide*, *salicylic acid* and other *antipyretics*. Among the *saline diaphoretics* are *solution* of *ammonium acetate, spirit of nitrous ether, potassium citrate.*

Pilocarpus is a powerful *sudorific* or special diaphoretic.

1341. **Expectorants** are medicines employed to aid or modify the secretions of the air passages and promote the expulsion of mucus and other fluids from the lungs and trachea.

Among the *sedative expectorants* are *ipecac* (an emetic), *tartar emetic* (a sedative), *pilocarpus* (a diaphoretic) and *lobelia* (a motor-depressant). *Grindelia* is also a sedative expectorant.

Among the *stimulant expectorants* (sometimes called blennor-rhetic) are *senega, quillaia, squill, sanguinaria, ammoniac, benzoin, balsam of Peru, balsam of Tolu, eucalyptus, oil of turpentine, copaiba, tar, terebene,* and *ammonium chloride.*

1342. **Astringents** are medicines used to diminish secretion, which they do by causing the contraction of the tissues with which they come in contact.

Among the *vegetable astringents* are *tannic and gallic acids* and drugs containing *tannins,* such as *nutgall, oak bark, catechu, kino, krameria, hæmatoxylon, geranium,* and *rhus glabra.*

Inorganic astringents include the soluble *salts of aluminum, silver, lead, zinc* and *copper,* and *certain iron salts.*

1343. **Antacids** are medicines which neutralize acids.

The *hydrates* and *carbonates* of *potassium, sodium, lithium* and *ammonium* and the *oxides, hydrates,* and *carbonates of calcium* and *magnesium* are antacids.

1344. **Antiseptics** are substances which prevent or arrest the decomposition of organic matter. They do this by preventing or arresting the development of the germs by which such decomposition is caused.

Disinfectants also arrest putrefaction and the formation of unwholesome or offensive products of decomposition; but while antiseptics simply prevent or arrest the development of the germs which cause the fermentation, putrefaction or other

organic changes, without destroying the products of decomposi-
tion that may have been already formed, and without injury to
healthy animal tissues, disinfectants always destroy the noxious
products of decomposition, and frequently have an injurious
or even destructive effect upon organic substances generally.

Among the most commonly employed *antiseptics* are *alcohol,
boric acid, salicylic acid, carbolic acid, benzoic acid, thymol, volatile
oils, as oil of eucalyptus* and *oil of cloves, quinine, populin, corrosive sub-
limate, etc.*

Among the most powerful *disinfectants* are *chlorine, bromine,
iodine, potassium permanganate, sulphurous acid* and the *sulphites.*

1345. Irritants are medicines applied locally to produce
counter-irritation, inflammation, vesication, suppuration, and
destruction of tissue.

Rubefacients are irritants producing powerful but tempor-
ary congestion of the surface to which they are applied. All *vola-
tile oils* are counter-irritants and rubefacients, but among the
most common rubefacients are *mustard, capsicum,* and *ammonia
liniment.*

Vesicants are remedies which raise blisters when applied to
the skin, such as *cantharis, croton oil,* etc.

Escharotics destroy the tissues with which they come in con-
tact, and therefore cause sloughing and eschar. Among the
escharotics are the *caustic alkalies, strong acids, bromine, zinc chlo-
ride, solution of nitrate of mercury,* etc.

1346. Demulcents are remedies administered internally for
their soothing effect upon irritated or inflamed surfaces.

Among them are *water, gums,* and *mucilages,* decoctions of
starch, barley, rice, althæa, etc.

1347. Emollients are bland *fatty substances, fomentations* or
poultices, glycerin, etc., applied externally to soften the skin.

CHAPTER LXXV.

1348. Dose Table of medicines in frequent use, including new remedies, in metric as well as apothecaries' weights and measures.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Absinthium, extr............	100 to 600 mGm	2 to 10 gr.
fluid extr.............	1 to 2 C. c.	15 to 30 min.
Abstracts, see each drug....		
Acetanilid.	250 to 500 mGm	4 to 8 gr.
Acetphenetidin......	200 to 500 mGm	3 to 8 gr.
Achillea, fl. ext.............	1 to 4 C. c.	15 to 60 min.
extr.	200 to 600 mGm	3 to 10 gr.
Acid, acet. dil..............	4 to 6 C. c.	1 to 1½ fl. dr.
arsenos	1 to 5 mGm	$\frac{1}{64}$ to $\frac{1}{12}$ gr.
" liquor..........	0.10 to 0 50 C. c.	2 to 8 min.
benzoic	300 mGm to 1 Gm	5 to 15 gr.
boric	300 mGm to 1 Gm	5 to 15 gr.
carbolic.............	60 to 200 mGm	1 to 3 gr.
gallic......	200 mGm to 1 Gm	3 to 15 gr.
" in albuminuria....	500 mGm to 4 Gm	8 to 60 gr.
hydriod., sir...........	1 to 5 C. c.	15 to 80 min.
hydrobrom. dil........	1 to 3 C. c.	15 to 50 min.
hydrochlor. dil........	0.50 to 2 C. c.	8 to 30 min.
hydrocyan. dil.	0.10 to 0.30 C. c.	2 to 5 min.
lactic	1 to 4 Gm	15 to 60 gr.
nitric. dil.............	0.50 to 2 C. c.	8 to 30 min.
nitrohydrochlor....	200 to 600 mGm	3 to 10 gr.
" dil......	0.30 to 1.30 C. c.	5 to 20 min.
phosph. dil...........	0.50 to 4 C. c.	8 to 60 min.
salicyl................	300 mGm to 1 Gm	5 to 15 gr.
sulph. arom...........	0.20 to 1 C. c.	3 to 15 min.
" dil...............	0.30 to 2 C. c	5 to 30 min.
tannic................	100 to 600 mGm	1 to 10 gr.
Aconiti fol................	50 to 250 mGm	1 to 4 gr.
" extr.............	15 to 30 mGm	¼ to ½ gr.
" fl. extr.........	0.05 to 0.20 C. c.	1 to 3 min.

NOTE.—The *dose for a child* is found by dividing the age in years at next birthday by 24 and multiplying the adult dose by the quotient.

The dose to be administered *hypodermatically* is one-half of the dose given by mouth.

The dose to be administered *by rectum* is 25 per cent. larger than that administered by mouth.

Remedies.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Aconiti fol. tinct............	0.50 to 1 C. c.	8 to 15 min.
rad	30 to 100 mGm	$\frac{1}{2}$ to 1$\frac{1}{2}$ gr.
'' abstr..............	15 to 50 mGm	$\frac{1}{4}$ to 1 gr.
'' extr........... ...	5 to 15 mGm	$\frac{1}{12}$ to $\frac{1}{4}$ gr.
'' fl. extr	0.05 to 0.15 C c.	1 to 2 min.
'' tinct	0.10 to 0.25 C. c.	2 to 4 min.
'' '' Fleming.......	0.05 to 0.20 C. c.	1 to 3 min.
Aconitina (pure, cryst.). ...	0.15 to 0.30 mGm	$\frac{1}{500}$ to $\frac{1}{200}$ gr.
Adonidin.....	8 to 30 mGm	$\frac{1}{8}$ to $\frac{1}{2}$ gr.
Aether...........	2 to 4 C. c.	$\frac{1}{2}$ to 1 fl. dr.
spir	2 to 5 C. c.	30 to 80 min.
'' comp.	2 to 4 C. c.	$\frac{1}{2}$ to 1 fl. dr.
Agaricin.	10 to 100 mGm	$\frac{1}{6}$ to 1$\frac{1}{2}$ gr.
Allii syr..................	5 to 15 C. c.	1 to 4 fl. dr.
Aloe, purgtive............	200 mGm to 1 Gm	3 to 15 gr.
decoct. comp..........	15 to 60 C. c.	$\frac{1}{2}$ to 2 fl. ozs.
extr..................	30 to 200 mGm	$\frac{1}{2}$ to 3 gr.
pil...................	3 to 6 pills	3 to 6 pills
tinct...	1 to 5 C. c.	15 to 80 min.
et asaf. pil............	2 to 5 pills	2 to 5 pills
'' ferri pil	2 to 4 pills	2 to 4 pills
'' mast. pil............	1 to 2 pills	1 to 2 pills
'' myrrh. pil..........	3 to 6 pills	3 to 6 pills
'' '' tinct.	5 to 10 C c.	1 to 2 fl dr.
Aloin	8 to 60 mGm	$\frac{1}{8}$ to 1 gr.
Alstonia, fl. extr...........	5 to 15 C. c.	1 to 4 fl. dr.
Alumen..................	300 mGm to 1 Gm	5 to 15 gr.
ustum	100 to 500 mGm	2 to 8 gr.
Ammoniacum	0.500 to 2 Gm	8 to 30 gr.
mist	15 to 30 C. c.	$\frac{1}{2}$ to 1 fl oz.
Ammoniæ spir	1 to 2 C. c.	15 to 30 min.
'' arom........	3 to 10 C c.	$\frac{1}{2}$ to 2$\frac{1}{2}$ fl. dr.
Ammonii benzoas..........	0 300 to 1 300 Gm	5 to 20 gr.
bromid	0 300 to 2 Gm	5 to 30 gr.
carb.........	200 to 500 mGm	3 to 8 gr.
chlorid	0.300 to 2.200 Gm	5 to 40 gr.
iodid..................	50 to 500 mGm	1 to 8 gr.
phosph............	0.500 to 1.500 Gm	8 to 24 gr.
picras...........	15 to 30 mGm	$\frac{1}{4}$ to $\frac{1}{2}$ gr.
sulph	200 mGm to 1 Gm	3 to 15 gr.
valer	100 to 500 mGm	2 to 8 gr.
Amyl nitris	2 to 5 drops	2 to 5 drops
Amylen. hydrat	1 to 4 Gm	15 to 60 gr.
Amylum iodat.............	0.20 to 2 Gm	3 to 30 gr.
Angustura, fl. extr.	1 to 2 50 C. c.	15 to 40 min.
Anthemis. extr...	100 to 650 mGm	2 to 10 gr.
fl. extr	2 to 4 C. c.	30 to 60 min.
Antifebrin................	250 to 500 mGm	4 to 8 gr.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Antipyrin { antipyretic.....	1 to 2 Gm	15 to 30 gr.
{ analgesic	500 mGm to 1 Gm	8 to 15 gr.
Ant. et pot. tart , diaphor...	4 to 10 mGm	$\frac{1}{16}$ to $\frac{1}{6}$ gr.
emetic	30 to 120 mGm	$\frac{1}{2}$ to 2 gr.
Antim. oxid.	50 to 250 mGm	1 to 4 gr.
Antim. oxysulph...........	30 to 100 mGm	$\frac{1}{2}$ to 2 gr.
pil. comp.............	1 to 3 pills	1 to 3 pills.
sulphid	30 to 100 mGm	$\frac{1}{2}$ to 2 gr.
sulphurat	30 to 100 mGm	$\frac{1}{2}$ to 2 gr.
vinum { expect.	0.06 to 0.50 C. c.	1 to 8 min.
{ emet	2 to 5 C. c.	30 to 80 min.
Apiol...................	200 to 300 mGm	3 to 5 gr.
Apocyn, fl extr............	0.20 to 2 C. c.	3 to 30 min.
Apomorphine	2 to 4 mGm	$\frac{1}{32}$ to $\frac{1}{16}$ gr.
Aqua amygd. amar...	5 to 15 C. c.	1 to 4 fl. dr.
camph.................	10 to 60 C. c.	$\frac{1}{2}$ to 2 fl. ozs.
chlori	5 to 15 C. c.	1 to 4 fl. dr.
creasoti	5 to 15 C. c.	1 to 4 fl. dr.
laurocerasi............	0.50 to 2 C. c.	8 to 30 min.
Areca, fl. extr.............	5 to 15 C. c.	1 to 4 fl. dr.
Argenti iodid..............	60 to 125 mGm	1 to 2 gr.
nitras.............. ..	15 to 30 mGm	$\frac{1}{4}$ to $\frac{1}{2}$ gr.
oxid.......	30 to 125 mGm	$\frac{1}{2}$ to 2 gr.
Arnicæ flor., fl extr.........	0.25 to 1.50 C. c.	5 to 20 min.
" tinct...........	1 to 3 C. c.	15 to 45 min.
rad., extr..............	60 to 200 mGm	1 to 3 gr.
" fl. extr............	0.30 to 1.50 C. c.	5 to 20 min.
" tinct	2 to 6 C. c.	30 to 90 min.
Arsenic—		
arsenous acid..........	1 to 3 mGm	$\frac{1}{64}$ to $\frac{1}{20}$ gr.
iodid	1 to 3 mGm	$\frac{1}{64}$ to $\frac{1}{20}$ gr.
sod. arsenate..........	1 to 3 mGm	$\frac{1}{64}$ to $\frac{1}{20}$ gr.
liqu. acid. arsen........	0.10 to 0.50 C. c.	2 to 8 min.
" arsen. et hydr. iod.	0.10 to 0.50 C. c.	2 to 8 min.
" pot. arsenitis. ...	0.10 to 0.50 C. c.	2 to 8 min.
" sol. arsenatis.....	0.10 to 0.50 C. c.	2 to 8 min.
Asafœtida	300 mGm to 1 Gm	5 to 15 gr.
mist	15 to 30 C. c.	$\frac{1}{2}$ to 1 fl. oz.
pil.....	2 to 6 pills	2 to 6 pills
tinct................ ...	2 to 4 C. c.	30 to 60 min.
Asarum, fl. extr...........	1 to 2 C. c.	15 to 30 min.
Asclepias, fl. extr..........	1 to 2 C. c.	15 to 30 min.
Aspidium..................	4 to 15 Gm	1 to 4 dr.
fl. extr..............	4 to 15 C. c.	1 to 4 fl. dr.
oleoresin....	1 to 4 Gm	15 to 60 gr.
Aspidosperma....	1 to 3 Gm	15 to 40 gr.
abstr	0.500 to 1 Gm	8 to 15 gr.
extr	200 to 500 mGm	3 to 8 gr.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Aspidosperma, fl. extr......	1 to 3 C. c.	15 to 45 min.
tinct............... ..	5 to 15 C. c.	1 to 4 fl. dr.
Aspidospermine............	60 to 300 mGm	1 to 3 gr
Atropine, and salts........	0.50 to 2 mGm	$\frac{1}{128}$ to $\frac{1}{32}$ gr.
Aurant, amar., fl extr......	1 to 10 C. c.	15 to 160 min.
tinct................:......	5 to 30 C. c.	1 to 4 fl. dr.
Auri et Sodii chlorid........	2 to 4 mGm	$\frac{1}{32}$ to $\frac{1}{16}$ gr.
Azedarach, fl. extr.........	1 to 5 C. c.	15 to 80 min.
Bebeerine, and salts	200 to 600 mGm	3 to 10 gr.
Bellad. fol.................	200 to 200 mGm	3 to 5 gr.
" abstr............	60 to 200 mGm	1 to 3 gr.
" extr............	6 to 20 mGm	$\frac{1}{10}$ to $\frac{1}{3}$ gr.
" fl. extr...........	0.15 to 0.30 C. c.	1 to 4 min.
" tinct.	0.40 to 1 C. c.	8 to 15 min.
rad	60 to 200 mGm	1 to 3 gr.
" abstr..............	30 to 100 mGm	$\frac{1}{2}$ to $1\frac{1}{2}$ gr.
" extr	5 to 10 mGm	$\frac{1}{12}$ to $\frac{1}{6}$ gr
" fl. extr...........	0.10 to 0.20 C. c.	1 to 3 min.
" tinct.....	0.20 to 0.60 C. c.	3 to 10 min.
Berberine, and salts........	0.200 to 1 Gm	3 to 15 gr.
Berberis, fl. extr...........	1 to 2 C. c.	15 to 30 min.
Betol.....................	1 to 2 Gm	15 to 30 gr.
Bismuthi citras.	0.200 to 1 Gm	3 to 15 gr.
et ammon. citr.........	0.100 to 1 Gm	1 to 15 gr.
oxid.....	0.200 to 1 Gm	3 to 15 gr.
salicyl.................	0 200 to 1 Gm	3 to 15 gr.
subcarb	0.200 to 2 Gm	3 to 30 gr.
subnitr................	0 200 to 2 Gm	3 to 30 gr.
tannas	0.200 to 2 Gm	3 to 30 gr.
valer	0 100 to 1 Gm	1 to 15 gr.
Boldus, fl. extr.............	0 20 to 1 C c.	3 to 15 min.
Brayera...................	8 to 15 Gm	2 to 4 dr.
fl extr	8 to 15 C. c.	2 to 4 fl. dr.
inf...............	60 to 250 C. c.	2 to 8 fl. ozs.
Bromum.......	30 to 100 mGm	$\frac{1}{2}$ to $1\frac{1}{2}$ gr.
Brucine, and salts...... ...	1 to 4 mGm	$\frac{1}{64}$ to $\frac{1}{16}$ gr.
Bryonia, fl. extr...........	1 to 2 C c.	15 to 30 min.
tinct	2 to 5 C c.	30 to 80 min.
Buchu, fl. extr....	2 to 10 C. c.	30 to 160 min.
Caffeine, and salts..........	60 to 300 mGm	1 to 4 gr.
Calamus, fl. extr...... ...	1 to 4 C. c.	15 to 60 min.
Calcii brom...............	0.300 to 2 Gm	5 to 30 gr.
carb......	1 to 4 Gm	15 to 60 gr.
hypophosph............	0.200 to 1 Gm	3 to 15 gr.
iodid	60 to 200 mGm	1 to 3 gr.
lactophosph. syr.........	5 to 10 C. c.	1 to 2 fl. dr.
phosphas..............	1 to 2 Gm	15 to 30 gr.
. sulphid...............	15 to 60 mGm	$\frac{1}{4}$ to 1 gr
Calcis syrupus............	1 to 2 C. c.	15 to 30 min.

Remedies.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Calend. fl. extr.............	1 to 4 C. c.	15 to 60 min.
tinct	4 to 15 C. c.	1 to 4 fl. dr.
Calomel.......	10 to 500 mGm	⅙ to 8 gr.
Calumba, extr..............	200 to 600 mGm	3 to 10 gr.
fl. extr.	1 to 4 C. c.	15 to 60 min.
tinct.................	5 to 15 C. c.	1 to 4 fl. dr.
Calx. Sulphurata..........	15 to 60 mGm	¼ to 1 gr.
Cambogia.........	60 to 250 mGm	1 to 4 gr.
Camphora.................	100 to 600 mGm	1½ to 10 gr.
aqua..................	15 to 60 C. c.	½ to 2 fl. ozs.
spir.................	0.50 to 2 C. c.	8 to 30 min.
monobrom.:..........	100 to 300 mGm	2 to 5 gr.
Canella, fl. extr...........	1 to 4 C. c.	15 to 60 min.
Cannabin, tannat...........	1 to 15 mGm	1/64 to ¼ gr.
Cannabis indica...........	200 to 400 mGm	3 to 6 gr.
" abstr.......	100 to 200 mGm	1½ to 3 gr.
" extr... ...	10 to 30 mGm	⅙ to ½ gr.
" fl. extr.....	0.20 to 0 40 C. c.	3 to 6 min.
" tinct........	0.50 to 2 C. c.	8 to 30 min.
Cantharis	30 to 60 mGm	½ to 1 gr.
fl. extr...............	0.03 to 0.06 C. c.	½ to 1 min.
tinct	0.50 to 1 C. c.	8 to 15 min.
Capsicum..................	60 to 200 mGm	1 to 3 gr.
fl. extr............	0.06 to 0.20 C. c.	1 to 3 min.
oleores.	10 to 30 mGm	⅙ to ½ gr.
tinct	0.50 to 1 C. c.	8 to 15 min.
Cascarilla, fl. extr.........	3 to 10 C. c.	40 to 150 min.
Castanea, fl. extr...........	3 to 10 C. c.	40 to 150 min.
Castoreum	0.400 to 1 Gm	6 to 15 gr.
tinct..............	1 to 4 C. c.	15 to 60 min.
Catechu.......	1 to 2 Gm	15 to 30 gr.
tinct	2 to 8 C. c.	½ to 2 fl. dr.
Caulophyll, fl. extr........	1 to 2 C. c.	15 to 30 min.
Chimaphila. fl. extr..... ...	2 to 4 C. c.	30 to 60 min.
Chinoidinum............. ...	0.200 to 2 Gm	3 to 30 gr.
Chinolina, and salts.·........	0.200 to 1 Gm	3 to 15 gr.
Chirata. fl. extr............	1 to 2 C. c.	15 to 30 min.
tinct...................	2 to 8 C c.	30 to 120 min.
Chloral........	0.200 to 1 Gm	3 to 15 gr.
croton	50 to 600 mGm	1 to 10 gr.
Chloralamid...............	1 to 2 Gm	15 to 30 gr.
Chloroform................	0.05 to 0.30 C. c.	1 to 5 min.
mist....................	5 to 15 C. c.	1 to 4 fl. dr.
spir..................	1 to 4 C. c.	15 to 60 min.
Chrysarobin....... ·	0.200 to 1 Gm	3 to 15 gr.
Cimicif., extr..............	0.100 to 0.500 Gm	2 to 8 gr.
fl extr...............	0.50 to 2 C. c.	8 to 30 min.
tinct....	2 to 4 C. c.	30 to 60 min.

| REMEDIES. | Single Adult Dose. | |
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Cinchona.................	1 to 4 Gm	15 to 60 gr.
abstr	0.500 to 2 Gm	8 to 30 gr.
extr..................	0.200 to 1 Gm	3 to 15 gr.
inf.	15 to 60 C. c.	½ to 2 fl. ozs.
fl. extr.	2 to 4 C. c.	30 to 60 min.
tinct.	4 to 12 C. c.	1 to 3 fl. dr.
" comp.............	4 to 12 C. c.	1 to 3 fl. dr.
Cinchonidina, and salts.....	0.060 to 2 Gm	1 to 30 gr.
Cinchonina, and salts.......	0.060 to 2 Gm	1 to 30 gr.
Cinnamomum.............	0.400 to 2 Gm	6 to 30 gr.
fl. extr.................	0.50 to 1 C. c.	8 to 15 min.
tinct.......	1 to 5 C. c.	15 to 80 min.
Cocaina and salts..........	10 to 60 mGm	⅙ to 1 gr.
Cocculus, fl. extr...........	0.05 to 0.50 C. c.	1 to 8 min.
Codeina......	30 to 100 mGm	½ to 2 gr.
Colch. rad................	100 to 500 mGm	2 to 8 gr.
" extr.............	30 to 100 mGm	½ to 2 gr.
" fl. extr..........	0.10 to 0.50 C.c.	2 to 8 min.
" tinct............	0.50 to 2 C. c.	8 to 30 min.
" vin...............	0.50 to 2 C. c.	8 to 30 min.
" sem. fl. extr.....	0.20 to 0.50 C. c.	3 to 8 min.
" tinct...........	0.50 to 2 C. c.	8 to 30 min.
" vin	0.50 to 2 C. c.	8 to 30 min.
Colocynthis.......	0.500 to 1 Gm	8 to 15 gr.
extr...	100 to 300 mGm	2 to 5 gr.
extr. comp............	100 to 300 mGm	2 to 5 gr.
fl. extr...	0.50 to 2 C. c.	8 to 30 min.
Comptonia, fl. extr..	2 to 8 C. c.	½ to 2 fl. dr.
Condurango, fl. extr........	0.50 to 2 C. c.	8 to 30 min.
Conhydrine, and salts......	1 to 3 mGm	¹⁄₆₄ to ¹⁄₂₀ gr.
Conii fruct..	100 to 400 mGm	2 to 6 gr.
" abstr.	60 to 200 mGm	1 to 3 gr.
" extr.............	20 to 60 mGm	⅓ to 1 gr.
" fl. extr.........	0.06 to 0.30 C. c.	1 to 5 min.
" tinct............	0.30 to 2 C. c.	5 to 30 min.
herb	0.300 to 1 Gm	4 to 15 gr.
" abstr	100 to 500 mGm	2 to 8 gr.
" extr........... .	50 to 150 mGm	¾ to 2 gr.
" fl. extr	0.20 to 1 C. c.	3 to 15 min.
" tinct........ ...	0.50 to 4 C. c.	8 to 60 min.
Coniina, and salts..........	1 to 2 mGm	¹⁄₆₄ to ¹⁄₃₂ gr.
Convallaria, fl. extr.........	1 to 2 C. c.	15 to 30 min.
Copaiba..................	1 to 4 C. c.	15 to 60 min.
massa	1 to 4 Gm	15 to 60 gr.
oleum.................	0.50 to 1 C. c.	8 to 15 min.
resina.................	0.200 to 1 Gm	3 to 15 gr.
Cornus. fl. extr	2 to 4 C. c.	30 to 60 min.
Corydalis, fl. extr...........	1 to 2 C. c.	15 to 30 min.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Coto	0.200 to 1 Gm	3 to 15 gr.
abstr.................	100 to 500 mGm	2 to 8 gr.
extr	50 to 200 mGm	1 to 3 gr.
fl. extr................	0.20 to 1 C. c.	3 to 15 min.
tinct	1 to 4 C. c.	15 to 60 min.
Cotoinum.................	10 to 30 mGm	$\frac{1}{6}$ to $\frac{1}{2}$ gr.
Creasotum.................	0.05 to 0.20 C. c.	1 to 3 min.
aqua	4 to 15 C. c	1 to 4 fl. dr.
Creta	1 to 5 Gm	15 to 80 gr.
mist....	30 to 60 C. c.	$\frac{1}{2}$ to 1 fl. ozs.
pulv. comp.............	0.500 to 2 Gm	8 to 30 gr.
Crocus	0.300 to 2 Gm	5 to 30 gr.
tinct	4 to 8 C. c.	1 to 2 fl. dr.
Croton-chloral.............	0.200 to 1 Gm	3 to 15 gr.
Cubeba	1 to 4 Gm	15 to 60 gr.
fl. extr	1 to 2 C. c	15 to 30 min.
oleum	0.50 to 1 C. c.	8 to 15 min.
oleores	0.50 to 2 C. c.	5 to 30 min.
tinct...................	4 to 8 C. c.	1 to 2 fl dr.
Cupri acet.................	30 to 200 mGm	$\frac{1}{2}$ to 3 gr.
sulph	30 to 500 mGm	$\frac{1}{2}$ to 8 gr.
Cuprum ammon	10 to 60 mGm	$\frac{1}{6}$ to 1 gr.
Curare	2 to 10 mGm	$\frac{1}{32}$ to $\frac{1}{6}$ gr.
Curarina.....	1 to 3 mGm	$\frac{1}{64}$ to $\frac{1}{20}$ gr.
Cypriped. fl. extr	1 to 4 C. c	15 to 60 min.
Damiana, fl. extr....	2 to 10 C. c	30 to 150 min.
Daturina.................	0.50 to 1 mGm	$\frac{1}{128}$ to $\frac{1}{64}$ gr.
Delphin., fl. extr.	0.06 to 0.20 C. c.	1 to 3 min.
Digitalinum................	1 to 2 mGm	$\frac{1}{64}$ to $\frac{1}{32}$ gr.
Digitalis....................	50 to 100 mGm	1 to 3 gr.
abstr..........	30 to 50 mGm	$\frac{1}{2}$ to 1 gr.
extr.	10 to 20 mGm	$\frac{1}{6}$ to $\frac{1}{3}$ gr.
fl. extr	0.05 to 0.20 C. c.	1 to 3 min.
infus.................	10 to 15 C. c.	2 to 4 fl dr.
tinct...................	0.30 to 1.30 C. c.	5 to 20 min.
Dioscorea, fl. extr..........	1 to 2 C. c.	15 to 30 min.
Dracont.. fl. extr	2 to 4 C. c.	30 to 60 min.
Drosera, fl extr.............	0.50 to 1 C. c.	8 to 15 min.
Duboisina. and salts........	0.50 to 1 mGm	$\frac{1}{128}$ to $\frac{1}{64}$ gr.
Dulcamara, extr............	0.300 to 1 Gm	5 to 15 gr.
fl extr.	4 to 8 C. c.	1 to 2 fl. dr.
Elaterin (U. S. P , 1880)... .	1 to 4 mGm	$\frac{1}{64}$ to $\frac{1}{16}$ gr.
tritur....	10 to 40 mGm	$\frac{1}{6}$ to $\frac{2}{3}$ gr.
Elaterium (U. S. P., 1870)..	4 to 30 mGm	$\frac{1}{16}$ to $\frac{1}{2}$ gr.
Emetina, and salts, diaphor.	0.50 to 2 mGm	$\frac{1}{128}$ to $\frac{1}{32}$ gr.
" " emet ...	8 to 15 mGm	$\frac{1}{8}$ to $\frac{1}{4}$ gr.
Ergota	1 to 4 Gm	15 to 60 gr.
extr................ ...	0 200 to 1 Gm	3 to 15 gr.

| REMEDIES. | Single Adult Dose. ||
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Ergota fl. extr..............	1 to 8 C. c.	15 min. to 2 fl. dr.
tinct....................	4 to 15 C. c.	1 to 4 fl. dr.
vin....................	4 to 15 C. c.	1 to 4 fl. dr.
Ergotinum.	0.200 to 1 Gm	3 to 15 gr.
Erigeron, fl. extr......	4 to 8 C. c.	1 to 2 fl. dr.
oleum........	0.30 to 1 C. c.	5 to 15 min.
Eriodictyon, fl. extr.... ...	1 to 2 C c.	15 to 30 min.
Erythroxylon, fl extr.......	2 to 4 C. c.	30 to 60 min.
Eserina, and salts..........	0.60 to 1.20 mGm	$\frac{1}{100}$ to $\frac{1}{50}$ gr.
Eucalyptus, fl. extr........	1 to 4 C. c.	15 to 60 min.
oleum.........	0 60 to 2 C. c.	10 to 30 min.
Euonymus, extr.....	200 to 500 mGm	3 to 8 gr.
fl. extr.................	1 to 4 C. c.	15 to 60 min.
Exalgin.....................	250 to 500 mGm	4 to 8 gr.
Extracts, see each drug.		
Fel bovis purif.............	200 to 400 mGm	3 to 6 gr.
Ferri acet. tinct...........	1 to 2 C. c.	15 to 30 min.
arsen..................	6 to 60 mGm	$\frac{1}{10}$ to 1 gr.
benzoas................	60 to 300 mGm	1 to 5 gr.
brom......	60 to 300 mGm	1 to 5 gr.
" syr................	0.50 to 3 C. c.	8 to 45 min.
carb. sacch............	0 250 to 1 Gm	4 to 15 gr.
" massa...........	0 250 to 1 Gm	4 to 15 gr.
chlorid.........	50 to 200 mGm	1 to 3 gr.
chlorid. liqu...........	0.10 to 0 60 C. c.	2 to 10 min.
" tinct...........	1 to 2 C. c.	15 to 30 min.
citr	300 to 600 mGm	5 to 10 gr.
" liqu...............	0 60 to 1 C. c.	10 to 15 min.
" vin.	4 C. c.	1 fl. dr.
et ammon. citr........	300 to 600 mGm	5 to 10 gr.
et " sulph.......	300 to 600 mGm	5 to 10 gr.
et " tartr	0.500 to 2 Gm	8 to 30 gr.
et cinch. citr...........	100 to 500 mGm	2 to 8 gr.
et pot. tart............	0 500 to 2 Gm	8 to 30 gr.
et quin. citr...........	100 to 500 mGm	2 to 8 gr.
et strych. citr.........	60 to 200 mGm	1 to 3 gr.
extr. pom...	250 to 500 mGm	4 to 8 gr.
ferrocyanid	200 to 400 mGm	3 to 6 gr.
hypophosphis	250 to 500 mGm	4 to 8 gr.
" syr......	4 C. c.	1 fl. dr.
iodid.......	30 to 150 mGm	$\frac{1}{8}$ to 2 gr.
" pil...............	1 to 5 pills	1 to 5 pills
" sacch....	120 to 500 mGm	2 to 8 gr.
" syr...............	1 to 4 C. c	15 to 60 min.
lactas.	100 to 500 mGm	2 to 8 gr.
liquor dialys....	0.50 to 2 C. c.	8 to 30 min.
mist. comp............	5 to 30 C. c.	1 to 8 fl. dr.
nitr. liqu..............	0.50 C. c.	8 min.
oxalas.................	200 to 300 mGm	3 to 5 gr.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Ferri oxid. hydrat..........	300 to 600 mGm	5 to 10 gr.
'' magnet.........	300 to 600 mGm	5 to 10 gr.
'' sacch..	0.300 to 1 Gm	5 to 16 gr.
'' '' syr........	4 C. c.	1 fl. dr.
pil. comp.	1 to 4 pills	1 to 4 pills
phosphas, 1870.........	200 to 300 mGm	3 to 5 gr.
phosphas, 1880........	200 to 300 mGm	3 to 5 gr.
pom. tinct......	1 to 2 C. c.	15 to 30 min.
pyrophosphas	200 to 300 mGm	3 to 5 gr.
subcarb...............	300 to 500 mGm	4 to 8 gr.
sulph................	100 to 250 mGm	2 to 4 gr.
'' exsicc...........	50 to 100 mGm	1 to 2 gr.
valer.................	50 to 200 mGm	1 to 3 gr.
vin. amar............	4 C. c.	1 fl. dr.
'' dulc	4 C. c.	1 fl dr.
Ferrum dialysat..........	0 50 to 2 C. c.	8 to 30 min.
reductum	60 to 300 mGm	1 to 5 gr.
Frangula. extr............	200 to 500 mGm	3 to 8 gr.
fl extr........... .	2 to 8 C. c.	½ to 2 fl dr.
Fluid extrs , see each drug...		
Fuchsin	60 to 200 mGm	1 to 3 gr.
Galbanum	0.500 to 1 Gm	8 to 16 gr.
pil. comp.............	2 to 3 pills	2 to 3 pills
Galla.................	0.50 to 1 Gm	8 to 16 gr.
tinct.................	2 to 4 C. c.	30 to 60 min.
Gelsemium	100 to 500 mGm	2 to 8 gr.
abstr................	60 to 250 mGm	1 to 4 gr.
extr........	20 to 60 mGm	⅓ to 1 gr.
fl. extr..............	0.10 to 0.50 C. c.	2 to 8 min.
tinct................	0.50 to 2 C. c.	8 to 30 min.
Gentiana extr............	0.200 to 1 Gm	3 to 15 gr.
fl. extr.............	2 to 4 C. c.	30 to 60 min.
inf. comp............	15 to 30 C. c.	½ to 1 fl. oz.
tinct.	2 to 8 C c.	½ to 2 fl. dr.
'' comp............	2 to 8 C. c.	½ to 2 fl. dr.
Geranium, fl. extr..........	1 to 4 C. c.	15 to 60 min.
Glonoin, 1 per cent. sol. ...	0 03 C. c.	½ min.
Glycyrrhiza. pulv. comp....	2 to 4 Gm	30 to 60 gr
Gossypium, fl. extr.........	2 to 4 C c.	15 to 60 min.
Granatum..............	2 to 5 Gm	30 to 80 gr.
decoct...............	60 to 120 C. c.	2 to 4 fl. ozs.
extr..	0.500 to 1 Gm	8 to 15 gr.
fl. extr..............	2 to 4 C. c.	30 to 60 min.
Grindelia, fl. extr....	2 to 4 C. c.	30 to 60 min.
Guaiaci lign.............	2 to 5 Gm	30 to 80 gr.
'' fl. extr.	2 to 4 C. c.	30 to 60 min.
resina................	0.500 to 1 Gm	8 to 16 gr.
'' tinct.............	2 to 4 C. c.	30 to 60 min.
'' '' ammon.......	2 to 4 C. c.	30 to 60 min.

Remedies.	Single Adult Dose.	
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Guaiacol	0.06 C. c.	1 min.
Guarana	1 to 4 Gm	15 to 60 gr.
fl. extr	2 to 4 C. c.	30 to 60 min.
Hæmatoxylon, decoct.......	30 to 60 C. c.	1 to 2 fl. ozs.
extr....................	250 to 600 mGm	4 to 10 gr.
fl. extr...........	2 to 4 C. c.	30 to 60 min.
Hamamelis, fl. extr........	4 to 8 C. c.	1 to 2 fl. dr.
Helleb nig , extr..........	50 to 200 mGm	1 to 3 gr.
fl. extr................	0.20 to 1 C. c.	3 to 15 min.
tinct....	1 to 4 C. c.	15 to 60 min.
Homatropina. hydrobrom...	0.30 to 1 mGm	$\frac{1}{200}$ to $\frac{1}{60}$ gr.
Humulus, extr	60 to 300 mGm	1 to 5 gr.
fl. extr........	2 to 4 C. c.	30 to 60 min.
tinct	4 to 8 C. c.	1 to 2 fl. dr.
Hydrangea, fl. extr........	2 to 4 C. c.	30 to 60 min.
Hydrarg chlorid. corros....	4 to 6 mGm	$\frac{1}{15}$ to $\frac{1}{10}$ gr.
"　　　mite......	0.005 to 1 Gm	$\frac{1}{15}$ to 15 gr.
cyanid	4 to 6 mGm	$\frac{1}{15}$ to $\frac{1}{10}$ gr.
iodid flav	4 to 50 mGm	$\frac{1}{15}$ to 1 gr.
"　rubr.............	3 to 8 mGm	$\frac{1}{20}$ to $\frac{1}{8}$ gr.
"　vir.............	4 to 50 mGm	$\frac{1}{15}$ to 1 gr.
massa	0 120 to 1 Gm	2 to 16 gr.
oxid. flav	3 to 5 mGm	$\frac{1}{20}$ to $\frac{1}{12}$ gr.
"　nigr.	3 to 5 mGm	$\frac{1}{20}$ to $\frac{1}{12}$ gr.
"　rubr	3 to 5 mGm	$\frac{1}{20}$ to $\frac{1}{12}$ gr.
pil	0.250 to 1 Gm	4 to 16 gr.
subsulph. flav	60 to 120 mGm	1 to 2 gr.
c. creta................	30 to 750 mGm	$\frac{1}{2}$ to 12 gr.
salicylas	60 mGm	1 gr.
ungu	0.250 to 1 Gm	4 to 16 gr.
Hydrastis..................	0.500 to 2 Gm	8 to 30 gr.
extr	100 to 300 mGm	2 to 5 gr.
fl. extr...	0.50 to 2 C. c	8 to 30 min.
tinct	2 to 8 C c.	$\frac{1}{2}$ to 2 fl. dr.
Hydroquinone	100 to 600 mGm	2 to 10 gr.
Hyoscina and salts........	0.10 to 0.50 mGm	$\frac{1}{600}$ to $\frac{1}{120}$ gr.
Hyoscvamina. and salts.....	0 30 to 1 mGm	$\frac{1}{200}$ to $\frac{1}{64}$ gr.
Hyoscyamus	200 to 500 mGm	3 to 8 gr.
abstr	60 to 3 0 mGm	1 to 5 gr.
extr	30 to 200 mGm	$\frac{1}{2}$ to 3 gr.
fl. extr................	0 50 to 2 C c.	8 to 30 min.
tinct	2 to 8 C. c.	$\frac{1}{2}$ to 2 fl. dr.
Hypnone........	0.06 C. c.	1 min.
Hypophosphitum syr.......	4 C. c	1 fl. dr.
Ichtyol	0 25 to 1.30 C. c.	4 to 20 min.
Ignatia	50 to 200 mGm	1 to 3 gr.
abstr	30 to 120 mGm	$\frac{1}{2}$ to 2 gr.
extr...................	15 to 30 mGm	$\frac{1}{4}$ to $\frac{1}{2}$ gr.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Ignatia, fl. extr.....	0.05 to 0.20 C. c.	1 to 3 min.
tinct	1 to 4 C. c.	15 to 60 min.
Iodoformum................	50 to 200 mGm	1 to 3 gr.
Iodol.......................	60 to 120 mGm	1 to 2 gr. ,
Iodum................	5 to 20 mGm	$\frac{1}{12}$ to $\frac{1}{3}$ gr.
liquor. com	0.20 to 0.50 C. c.	3 to 8 min.
tinct	.30 to 1 30 C. c.	5 to 20 min.
Ipecac., expect.............	10 to 60 mGm	$\frac{1}{6}$ to 1 gr.
emet....	1 to 2 Gm	15 to 30 gr.
abstr. expect...........	5 to 30 mGm ·	$\frac{1}{12}$ to $\frac{1}{2}$ gr.
" emet.......	0.500 to 1 Gm	8 to 15 gr.
et opii pulv	200 to 600 mGm	3 to 10 gr.
" " tinct	0.20 to 0 60 C. c.	3 to 10 min.
fl. extr., expect........	0.10 to 0 60 C. c.	$\frac{1}{6}$ to 1 min.
" emet	1 to 4 C. c.	15 to 60 min.
syr. expect............	0.60 to 2 C. c	10 to 30 min.
" emet....	4 to 15 C. c.	1 to 4 fl. dr.
vin. expect.............	0.30 to 1 C. c.	5 to 15 min.
" emet.............	10 to 25 C. c.	3 to 6 fl. dr.
Iris versicolor, extr...	200 to 300 mGm	3 to 5 gr.
" fl. extr......	1 to 2 C. c.	15 to 30 min.
Jalapa.....................	1 to 2 Gm	15 to 30 gr.
abstr	0 500 to 1 Gm	8 to 15 gr.
extr. B. P..............	0.500 to 1 Gm	8 to 15 gr.
" alc..............	200 to 400 mGm	3 to 6 gr.
fl. extr..............	1 to 2 C. c.	15 to 30 min.
pulv. comp.............	0.500 to 2 Gm	8 to 30 gr.
resina	120 to 300 mGm	2 to 5 gr.
tinct	4 to 10 C. c.	1 to 2$\frac{1}{2}$ fl. dr.
Juglans, extr..............	0.500 to 2 Gm	8 to 30 gr.
fl. extr...............	4 to 8 C. c.	1 to 2 fl. dr.
Juniperus, fl. extr	2 to 4 C. c.	30 to 60 min.
Kairina....................	0.400 to 1.300 Gm	6 to 20 gr.
Kamala........	4 to 8 Gm	1 to 2 dr.
fl. extr........	4 to 8 C. c.	1 to 2 fl. dr.
Kino................ ..... ·	0.500 to 1 Gm	8 to 15 gr.
tinct	2 to 8 C. c.	$\frac{1}{2}$ to 2 fl. dr.
Krameria, ext..............	0 250 to 1 Gm	4 to 15 gr.
fl. extr..............	2 to 4 C. c.	30 to 60 min.
syr....	4 to 15 C. c.	1 to 4 fl. dr.
tinct............	2 to 8 C. c.	$\frac{1}{2}$ to 2 fl. dr.
Lactuca, extr..............	120 to 500 mGm	2 to 8 gr.
fl. extr...........	1 to 4 C. c.	15 to 60 min.
Lactucarium	0.50 to 4 Gm	8 to 60 gr
fl. extr.....	0.30 to 2 C. c.	5 to 30 min.
syr....................	4 to 15 C. c.	1 to 4 fl dr.
Lavand., tinct. comp.......,	2 to 4 C. c.	30 to 60 min.
Leonurus, fl. extr.....	2 to 4 C. c.	30 to 60 min.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Leptandra.................	1 to 2 Gm	15 to 30 gr.
extr................	50 to 200 mGm	1 to 6 gr.
fl. extr......	1 to 2 C. c.	15 to 30 min.
Liqu. acidi arsen..........	0.10 to 0.50 C. c.	2 to 8 min.
ammon. acet.	4 to 30 C. c.	1 to 8 fl. dr.
arseni et hydr. iod......	0.10 to 0.50 C. c.	2 to 8 min.
ferri acet.......	0.10 to 0.50 C. c.	2 to 8 min.
" chlor.............	0.10 to 0.60 C. c.	2 to 10 min.
" citr	0.50 to 1 C. c.	8 to 15 min.
" dialys............	0.50 to 2 C. c.	8 to 30 min.
" nitrat	0.50 to 1 C. c.	8 to 15 min.
pepsini................	8 to 15 C. c.	2 to 4 fl. dr.
potassæ	0.30 to 2 C. c.	5 to 30 min.
pot arsenit............	0.10 to 0 50 C c.	2 to 10 min.
" citr...............	8 to 15 C. c.	2 to 4 fl. dr.
sodæ	0.30 to 2 C. c.	5 to 30 min.
sodii arsenat	0.10 to 0.50 C. c.	2 to 8 min.
Lithii benzoas..............	100 to 300 mGm	1 to 5 gr.
brom	60 to 200 mGm	1 to 3 gr.
carb......	100 to 400 mGm	1 to 6 gr.
chlorid	100 to 300 mGm	1 to 5 gr.
citr...................	100 to 300 mGm	1 to 5 gr.
salicyl................	100 to 500 mGm	1 to 8 gr.
Lobelia, acet.......	1 to 4 C. c.	15 to 60 min.
fl. extr................	0.20 to 2 C. c.	3 to 30 min.
tinct................ ...	0 50 to 4 C. c.	8 to 60 min.
Lupulinum	0.300 to 1 Gm	5 to 15 gr.
fl. extr	0 30 to 1 C. c.	5 to 15 min.
oleores	100 to 250 mGm	2 to 4 gr
tinct..................	2 to 8 C. c.	½ to 2 fl. dr.
Magnesia........	0.50 to 2 Gm	8 to 30 gr.
Magnes. carb....	1 to 5 Gm	15 to 80 gr.
citr. granul............	8 to 30 Gm	¼ to 1 oz.
et asaf. mist...........	4 to 15 C. c.	1 to 4 fl. dr.
sulphas...............	8 to 30 Gm	¼ to 1 oz.
sulphis	1 to 2 Gm	15 to 30 gr.
Maidis stigm., fl. extr......	4 C. c	1 fl. dr.
Mangani sulph.....	100 to 500 mGm	2 to 8 gr.
Manna	30 to 60 Gm	1 to 2 ozs.
Massa copaibæ.....	1 to 4 Gm	15 to 60 gr.
ferri carb.....	0.250 to 1 Gm	4 to 16 gr.
hydrarg........	0.120 to 1 Gm	2 to 16 gr.
Matico, fl. extr.............	2 to 4 C. c.	30 to 60 min.
tinct.................	4 to 15 C. c.	1 to 4 fl. dr.
Mentha pip., oleum........	1 to 3 drops	1 to 3 drops
spir	0 30 to 1 C. c.	5 to 15 min.
Methacetin................	200 to 500 mGm	3 to 8 gr.
Methylal	1 to 2 C. c.	15 to 130 min.

Remedies.	Single Adult Doses.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Methysticum, fl. extr.........	1 to 4 C. c.	· 15 to 60 min.
Mezereum, fl. extr	0.30 to 1 C. c.	· 5 to 15 min.
Mist. ammon...............	15 to 30 C. c.	4 to 8 fl. dr.
asafoet	15 to 30 C. c.	4 to 8 fl. dr.
chloroformi.............	5 to 15 C. c.	1 to 4 fl. dr.
cretæ comp.............	30 to 60 C. c.	1 to 2 fl. ozs.
ferri comp.............	4 to 30 C. c.	1 to 8 fl. dr.
ferri et ammon. acet....	8 to 15 C. c.	2 to 4 fl. dr.
glycyrrh. comp.........	4 to 15 C. c.	1 to 4 fl. dr.
magnes. et asaf.	4 to 15 C. c.	1 to 4 fl. dr.
pot. citr	8 to 30 C. c.	2 to 8 fl. dr.
rhei et sodæ............	8 to 30 C c.	2 to 8 fl. dr.
Morphina and salts.........	4 to 30 mGm	$\frac{1}{16}$ to $\frac{1}{2}$ gr.
pulv. comp.............	0.500 to 1 Gm	8 to 15 gr.
Moschus....	0.100 to 1 Gm	1½ to 15 gr.
tinct	1 to 8 C c.	15 to 120 min.
Myrica	2 to 4 Gm	30 to 60 gr.
fl. extr.........	2 to 4 C. c.	30 to 60 min.
Naphthalin....	0.300 to 2 Gm	5 to 30 gr.
Narceina.................	10 to 30 mGm	$\frac{1}{6}$ to $\frac{1}{2}$ gr.
Narcotina...............	20 to 60 mGm	$\frac{1}{3}$ to 1 gr.
Nitroglycerin, 1 per cent. sol.	1 drop	1 drop
Nux Vomica......	50 to 300 mGm	1 to 5 gr.
abstr.................	30 to 120 mGm	$\frac{1}{2}$ to 2 gr.
extr.............	15 to 60 mGm	$\frac{1}{4}$ to 1 gr.
fl. extr	0.05 to 0.30 C. c.	1 to 5 min.
tinct.................	0.30 to 1.30 C. c.	5 to 20 min.
Oleoresina aspidii.........	1 to 4 Gm	15 to 60 gr.
capsici................	10 to 30 mGm	$\frac{1}{6}$ to $\frac{1}{2}$ gr.
cubebæ............. .	0.500 to 2 Gm	8 to 30 gr.
lupulini...............	100 to 250 mGm	2 to 4 gr.
piperis...............	60 to 200 mGm	1 to 3 gr.
zingiberis	60 to 200 mGm	1 to 3 gr.
Oleum anisi	0.20 to 0.50 C. c.	3 to 8 min.
cajuputi...............	0.10 to 0.50 C c.	1 to 8 min.
cari	0 10 to 0.50 C. c.	1 to 8 min.
chenopodii.............	0.25 to 0.50 C. c.	4 to 8 min.
copaibæ...............	0.50 to 1 C. c.	8 to 15 min.
cubebæ...............	0.50 to 1 C. c.	8 to 15 min.
erigerontis.......... ..	0.30 to 1 C. c.	5 to 15 min.
eucalypti......	0 60 to 2 C. c.	10 to 30 min.
foeniculi...............	0.20 to 0.50 C. c.	3 to 8 min.
menthæ pip.............	1 to 3 drops	1 to 3 drops
morrhuæ...............	15 C. c.	$\frac{1}{2}$ fl. oz.
olivæ....	15 to 60 C. c.	$\frac{1}{2}$ to 2 fl. ozs.
phosphorat	0.06 to 0 20 C. c.	1 to 3 min.
ricini....	8 to 30 C. c.	$\frac{1}{4}$ to 1 fl. oz.
sabinæ................	2 to 5 drops	2 to 5 drops

Remedies.	Single Adult Dose.	
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Oleum, santali.............	0.50 to 2 C. c.	8 to 30 min.
terebinth..............	0.30 to 1 C. c.	5 to 15 min.
tiglii	¼ to 2 drops.	¼ to 2 drops
valer........	1 to 2 drops.	1 to 2 drops
Opium....................	30 to 60 mGm	½ to 1 gr.
acet....................	0.30 to 0.60 C. c.	5 to 10 min.
extr....................	15 to 30 mGm	¼ to ½ gr.
pil. (1 gr.).............	1 pill.	1 pill
tinct....................	0.30 to 0.60 C. c.	5 to 10 min.
" camph.............	4 to 15 C. c.	1 to 4 fl dr.
" deod............	0.30 to 0.60 C. c.	5 to 10 min.
vin....................	0 30 to 0.60 C. c.	5 to 10 min.
Pancreatin............	100 to 300 mGm	2 to 5 gr.
Papain....	60 to 250 mGm	1 to 4 gr.
Papaver, extr..............	60 to 300 mGm	1 to 5 gr.
fl. extr..............	2 to 8 C. c.	½ to 2 fl. dr.
Paraldehyd..	2 to 4 C. c.	½ to 1 fl. dr.
Pareira. fl. extr............	2 to 4 C c.	½ to 1 fl. dr.
Pelletierin tannate	0.200 to 0 500 Gm	3 to 8 gr.
Pepsin, pure (2,000)........	60 to 120 mGm	1 to 2 gr.
liquor.	4 to 15 C. c.	1 to 4 fl. dr.
sacch. (50).............	0.100 to 10 Gm	2 to 150 gr.
Phenacetin	0.200 to 1 Gm	3 to 15 gr.
Phosphorus................	0.60 to 1.20 mGm	$\frac{1}{100}$ to $\frac{1}{50}$ gr.
oleum................	0.06 to 0.20 C. c.	1 to 3 min.
pil............⁰......	1 pill	1 pill
Physostigma............ ..	30 to 60 mGm	½ to 1 gr.
abstr.................	15 to 30 mGm	¼ to ½ gr.
extr.	4 to 10 mGm	$\frac{1}{16}$ to ⅙ gr.
fl. extr................	0.05 to 0.20 C. c.	1 to 3 min.
tinct	1 to 2 C. c.	15 to 30 min.
Physostigmina, and salts...	0.60 to 1.20 mGm	$\frac{1}{100}$ to $\frac{1}{50}$ gr.
Phytolacca, bacca., fl. extr..	0.50 to 2 C. c	8 to 30 min.
rad....................	50 to 350 mGm	1 to 6 gr.
" abstr..............	30 to 200 mGm	½ to 3 gr.
" extr.	20 to 150 mGm	⅓ to 2 gr
" fl. extr.............	0.50 to 2 C c.	8 to 30 min.
" tinct..............	2 to 8 C. c.	½ to 2 fl. dr.
Picrotoxin........	0.50 to 1 mGm	$\frac{1}{128}$ to $\frac{1}{64}$ gr.
Pilocarpina, and salts.......	5 to 20 mGm	$\frac{1}{12}$ to ⅓ gr.
Pilocarpus.......	2 to 4 Gm	30 to 60 gr.
abstr.....	1 to 2 Gm	15 to 30 gr.
extr....................	100 to 500 mGm	2 to 8 gr
fl extr............. ..	2 to 4 C. c.	30 to 60 min.
Piluiæ aloes..............	1 to 3 pills	1 to 3 pills
" et asafoet......	2 to 5 pills	2 to 5 pills
" et ferri........	1 to 3 pills	1 to 3 pills
" et mast........	1 to 3 pills	1 to 3 pills

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Pilulæ aloes et myrrhæ......	2 to 5 pills	2 to 5 pills
antim. comp...........	1 to 3 pills	1 to 3 pills
asafœtidæ........	1 to 6 pills	1 to 6 pills
cathart. comp.........	1 to 4 pills	1 to 4 pills
copaibæ.............	1 to 4 Gm	15 to 60 gr.
ferri carb.............	0 250 to 1 Gm	4 to 15 gr.
" comp............	2 to 5 pills	2 to 5 pills
galbani comp..........	1 to 5 pills	1 to 5 pills
hydrarg	0.129 to 1 Gm	2 to 15 gr.
opii (1 gr.)...·......	1 pill	1 pill
phosphori.............	1 to 2 pills	1 to 2 pills
rhei	2 to 5 pills	2 to 5 pills
" comp........... ..	2 to 5 pills	2 to 5 plls
Piper....................	0.300 to 1 300 Gm	5 to 20 gr.
oleoresina.............	15 to 60 mGm	⅓ to 1 gr.
Piperina................	60 to 500 mGm	1 to 8 gr.
Piscidia, fl. extr...........	1 to 2 C. c.	15 to 30 min.
Plumbi acet...............	50 to 250 mGm	1 to 4 gr.
iod...................	30 to 250 mGm	½ to 4 gr.
Podophyllum..	300 to 600 mGm	5 to 10 gr.
abstr..................	100 to 250 mGm	2 to 4 gr.
extr....	60 to 200 mGm	1 to 3 gr.
fl. extr.............	0.50 to 1.50 C. c.	8 to 20 min.
resina........	10 to 30 mGm	⅙ to ½ gr
tinct..................	2 to 4 C. c.	30 to 60 min.
Populin..................	60 to 300 mGm	1 to 5 gr.
Populus, fl. extr...........	2 to 4 C. c.	30 to 60 min.
Potassa sulphurata.........	60 to 250 mGm	1 to 4 gr.
Potassæ liquor..	0.50 to 2 C. c.	8 to 30 min.
Potassii acet.............	0.500 to 1 Gm	8 to 15 gr.
arsenit. liquor...... ...	0.10 to 0.50 C. c.	2 to 8 min.
bicarb...............	1 to 2 Gm	15 to 30 gr.
bichrom..............	10 mGm	⅙ gr.
bitartr	4 to 8 Gm	1 to 2 dr.
bromid	1 to 8 Gm	15 gr. to 2 dr.
carb	0.500 to 1 Gm	8 to 15 gr.
chloras....	0.500 to 1 Gm	8 to 15 gr.
citras	1 to 2 Gm	15 to 30 gr.
cyanid	8 mGm	⅛ gr.
et sodii tartr...........	8 to 30 Gm	¼ to 1 oz.
hypophosph........... ..	0.500 to 2 Gm	8 to 30 gr.
iodid	0.120 to 1 Gm	2 to 15 gr.
nitras..................	1 to 15 Gm	15 gr. to 4 dr.
nitris.................	120 to 200 mGm	2 to 3 gr.
sulphas...............	1 to 10 Gm	15 to 150 gr.
sulphid...............	30 to 200 mGm	½ to 3 gr.
sulphis........	1 to 2 Gm	15 to 30 gr.
tartras.................	4 to 15 Gm	1 to 4 dr.

| REMEDIES. | Single Adult Dose. | |
	Metric Weights and Measures.	Old Apothecaries' Weights and Measures.
Prunus virg., inf..	30 to 60 C. c.	1 to 2 fl. ozs.
fl. extr.....	2 to 4 C. c.	30 to 60 min.
syr.	8 to 30 C c.	½ to 1 fl oz.
Pulvis antimonialis.........	150 to 600 mGm	2 to 10 gr.
aromat....	0.500 to 2 Gm	8 to 30 gr.
'' fl. extr	0.50 to 2 C. c.	8 to 30 min.
cretæ comp............	0.500 to 2 Gm	8 to 30 gr.
glycyrrh. comp.	2 to 4 Gm	30 to 60 gr.
ipecac et opii....... ..	0.300 to 1 Gm	5 to 15 gr.
jalapæ comp	2 to 4 Gm	30 to 60 gr.
morph. comp..........	0.500 to 1 Gm	8 to 15 gr.
rhei comp.............	2 to 4 Gm	30 to 60 gr.
Pyrocatechin	120 to 600 mGm	2 to 10 gr.
Quassia, extr..............	60 to 300 mGm	1 to 5 gr.
fl extr	1 to 4 C. c	15 to 60 min.
tinct	4 to 8 C. c.	1 to 2 fl dr.
Quercus, fl. extr...........	2 to 4 C. c.	½ to 1 fl. dr.
Quinidina, and salts........	0 050 to 2 Gm	1 to 30 gr.
Quinina, and salts..........	0.050 to 2 Gm	1 to 30 gr.
Quininæ arsenas	6 to 30 mGm	1⁄16 to ½ gr.
Resina copaibæ.............	100 to 600 mGm	2 to 10 gr.
cubebæ................	100 to 600 mGm	2 to 10 gr.
jalapæ.................	100 to 300 mGm	2 to 5 gr.
podophylli	6 to 30 mGm	1⁄16 to ½ gr.
scammonii......	100 to 30 0 mGm	2 to 5 gr.
Resorcin	0 300 to 2 Gm	5 to 30 gr
Rhamnus cath., fl. extr......	2 to 4 C. c.	30 to 60 min.
pursh . extr	200 to 500 mGm	3 to 8 gr.
'' fl. extr	2 to 8 C. c.	30 to 120 min.
Rheum.......	0 500 to 2 Gm	8 to 30 gr.
extr..................	0.300 to 1 Gm	5 to 15 gr.
fl. extr	2 to 8 C c	½ to 2 fl. dr.
et sodæ mist...........	4 to 30 C c.	1 to 8 fl. dr.
pil...................	1 to 5 pills	1 to 5 pills
'' comp............. ..	1 to 3 pills	1 to 3 pills
pulv comp...	1 to 4 Gm	15 to 60 gr
syr	4 C. c.	1 fl. dr.
'' arom..............	4 C. c.	1 fl. dr
tinct	4 to 15 C c.	1 to 4 fl. dr.
'' arom............ ..	4 to 15 C. c.	1 to 4 fl. dr.
'' dulc	4 to 15 C c.	1 to 4 fl. dr.
vin	4 to 15 C. c.	1 to 4 fl dr.
Rhus glabra, fl. extr........	2 to 4 C. c.	30 to 60 min.
Rosa, fl. extr	2 to 4 C. c.	30 to 60 min.
Rubus, fl. extr.....	4 to 8 C. c.	1 to 2 fl dr.
syr	8 to 15 C. c.	2 to 4 fl. dr.
Rumex. fl. extr.............	2 to 4 C. c.	30 to 60 min.

| REMEDIES. | Single Adult Dose. | |
	Metric Weights and Measures.	Old Apothecaries' Weight and Measures.
Sabina, fl. extr.............	0.30 to 1.50 C. c.	5 to 20 min.
oleum	2 to 5 drops	2 to 5 drops.
Salicin.........	1 to 2 Gm	15 to 30 gr.
Salol......................	0.300 to 4 Gm	5 to 60 gr.
Sanguinaria	0.100 to 1 Gm	2 to 15 gr.
abstr	50 to 400 mGm	1 to 6 gr.
acet..................	1 to 2 C c.	15 to 30 min.
fl. extr.	0.50 to 1 C. c.	8 to 15 min.
Sanguinarina, and salts.....	1 to 3 mGm	$\frac{1}{20}$ to $\frac{1}{20}$ gr.
Santonica	1 to 4 Gm	15 to 60 gr.
fl. extr................	1 to 2 C. c.	15 to 30 min.
Santonin..................	50 to 250 mGm	1 to 4 gr.
album	100 to 500 mGm	2 to 8 gr.
Sapo	0.300 to 1 Gm	5 to 15 gr.
Sarsap. dec. comp	90 to 150 C. c.	3 to 5 fl. ozs.
fl. ext...............	4 to 8 C. c.	1 to 2 fl. dr.
" comp...........	2 to 8 C. c.	$\frac{1}{2}$ to 2 fl. dr.
syr.- "	4 to 15 C. c.	1 to 4 fl. dr.
Scammonium	0.500 to 1 Gm	8 to 15 gr.
resina................	100 to 300 mGm	2 to 5 gr.
Scilla.....................	0.060 to 1 Gm .	1 to 15 gr.
acet	0.60 to 2 C. c.	10 to 30 min.
fl. extr................	0.20 to 1 C. c.	3 to 15 min.
syr......	2 to 4 C. c.	30 to 60 min.
" comp...............	2 to 4 C. c.	30 to 60 min.
tinct	0.50 to 2 C. c.	8 to 30 min.
Scoparius, fl. extr	2 to 4 C. c.	15 to 60 min.
Scutellaria, fl. extr.........	4 to 8 C. c.	1 to 2 fl. dr.
Senega	0.500 to 1 Gm	8 to 15 gr.
abstr......	200 to 500 mGm	3 to 8 gr.
fl. extr............ ...	0.50 to 1 C. c.	8 to 15 min.
syr....	4 to 8 C. c.	1 to 2 fl. dr.
Senna	2 to 8 Gm	30 to 120 gr.
conf..................	4 to 8 Gm	1 to 2 dr.
fl. extr	4 to 15 C. c.	1 to 4 fl. dr.
inf. comp	30 to 60 C. c.	1 to 2 fl. ozs.
syr	4 to 15 C. c.	1 to 4 fl. dr.
Serpentaria	2 to 4 Gm	30 to 60 gr.
fl. extr................	2 to 4 C. c.	30 to 60 min.
tinct	4 to 8 C. c.	1 to 2 fl. dr.
Sodæ liquor................	0.50 to 2 C. c.	8 to 30 min.
Sodii acet	1 to 4 Gm	15 to 60 gr.
arsenas..............	1 to 3 mGm	$\frac{1}{64}$ to $\frac{1}{20}$ gr.
benzoas...............	1 to 2 Gm	15 to 30 gr.
bicarb.	1 to 2 Gm	15 to 30 gr.
bisulphis.............	1 to 2 Gm	15 to 30 gr.
boras.....	1 to 2 Gm	15 to 30 gr.
bromid	1 to 4 Gm	15 to 60 gr.

	Single Adult Dose.	
REMEDIES.	*Metric Weights and Measures.*	*Old Apothecaries' Weights and Measures.*
Sodii carb..................	1 to 2 Gm	15 to 30 gr.
" exsicc...........	0.500 to 1 Gm	8 to 15 gr.
chloras................	0.500 to 1 Gm	8 to 15 gr.
hypophosphis..........	0.500 to 1 Gm	8 to 15 gr.
hyposulphis............	0.500 to 1 Gm	8 to 15 gr.
iodid	1 to 2 Gm	15 to 30 gr.
nitris.................	100 to 200 mGm	2 to 3 gr.
phosph................	0.500 to 4 Gm	8 to 60 gr.
salicylas..	0.300 to 2 Gm	5 to 30 gr.
santoninas.....	100 to 500 mGm	2 to 8 gr.
sulphas....	8 to 30 Gm	2 to 8 dr.
sulphis................	1 to 4 Gm	15 to 60 gr.
valeras...........	100 to 500 mGm	2 to 8 gr.
Sparteina.......	15 to 100 mGm	¼ to 2 gr.
Spigelia	2 to 4 Gm	30 to 60 gr.
fl. ext.................	2 to 4 C. c.	30 to 60 min.
et senna. fl. extr.......	4 to 8 C. c.	1 to 2 fl. dr.
Spir. ætheris.	2 to 4 C. c.	30 to 60 min.
" comp........	2 to 4 C. c.	30 to 60 min.
" nitros........	2 to 8 C. c.	30 to 120 min.
ammoniæ..............	0.50 to 2 C. c.	8 to 30 min.
" arom....	1 to 4 C. c.	15 to 60 min.
camphoræ..............	0.50 to 2 C. c.	8 to 30 min.
chloroformi............	1 to 4 C. c.	15 to 60 min.
lavand. comp..	2 to 4 C. c.	30 to 60 min.
menthæ pip.............	2 to 4 C. c.	30 to 60 min.
Stillingia, fl. extr............	4 to 8 C. c.	1 to 2 fl. dr.
" comp ...	4 to 8 C. c.	1 to 2 fl. dr.
syr. "	4 to 15 C. c.	1 to 4 fl. dr.
Stramon. fol., extr.........	30 to 60 mGm	½ to 1 gr.
" fl. extr.......	0.10 to 0.50 C. c.	2 to 8 min.
sem. abstr.	20 to 60 mGm	⅓ to 1 gr.
" extr............	10 to 40 mGm	⅙ to ⅔ gr.
" fl. extr	0.05 to 0.30 C. c.	1 to 5 min.
" tinct	0.50 to 2 c.	8 to 30 min.
Strophantin...............	0.40 to 1 mGm	$\frac{1}{100}$ to $\frac{1}{60}$ gr.
Strophanthus, tinct. (10 %)..	0.03 to 0.50 C. c.	½ to 8 min.
Strychnina, and salts	0.40 to 3 mGm	$\frac{1}{160}$ to $\frac{1}{20}$ gr.
Sulfonal	1 to 3 Gm	15 to 45 gr.
Sulphur...................	4 to 15 Gm	1 to 4 dr.
Sumbul, fl. extr...........	1 to 2 C. c.	15 to 30 min.
tinct.................	2 to 8 C. c.	30 to 120 min.
Syrup. acidi hydriod........	1 to 5 C. c.	15 to 80 min.
allii	4 to 15 C. c.	1 to 4 fl dr.
calcii lactophosph......	4 to 8 C. c.	1 to 2 fl. dr.
calcis.............. ..	1 to 2 C. c.	15 to 30 min.
ferri brom.............	1 to 4 C. c.	15 to 60 min.
" iod........... ...	1 to 4 C. c.	15 to 60 min.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Syrup ferri oxidi sacch......	4 C. c.	1 fl. dr.
" hypophosph.....	4 C. c.	1 fl. dr.
hypophosphitum........	4 C. c.	1 fl. dr.
c. ferro...............	4 C. c.	1 fl. dr.
ipecac................	2 to 15 C. c.	½ to 4 fl. dr.
krameriæ.............	2 to 15 C. c.	½ to 4 fl. dr.
lactucarii	4 to 8 C. c.	1 to 2 fl. dr.
rhei..................	4 to 15 C. c.	1 to 4 fl. dr.
" arom....	4 to 15 C. c.	1 to 4 fl. dr.
rosæ.................	4 to 8 C. c.	1 to 2 fl. dr.
rubi..................	4 to 8 C. c.	1 to 2 fl. dr.
sarsap. comp..........	4 to 15 C. c.	1 to 4 fl. dr.
scillæ................	2 to 4 C. c.	30 to 60 min.
" comp......	1 to 4 C. c.	15 to 60 min.
senegæ	4 to 8 C. c.	1 to 2 fl. dr.
sennæ................	4 to 15 C. c.	1 to 4 fl. dr.
Taraxacum, extr..........	0.300 to 1 Gm	5 to 15 gr.
fl. extr........	2 to 8 C. c.	30 to 120 min.
Terebene	0.30 to 1.30 C. c.	5 to 20 min.
Terebinthina.............	0.500 to 2 Gm.	8 to 30 gr.
oleum.......	0.30 to 1 C. c.	5 to 15 min.
Terpine	200 to 600 mGm	3 to 10 gr.
Terpinol.........	120 mGm	2 gr.
Thalline.................	0.100 to 1 Gm	2 to 15 gr.
Theina, and salts..........	60 to 300 mGm	1 to 5 gr.
Tiglii oleum.............	10 to 100 mGm	⅙ to 1½ gr.
Tincturæ, see drugs........		
Toxicodendron, fl. extr.	0.06 to 0.30 C. c.	1 to 5 min.
Trit. repens, fl. extr........	4 to 15 C. c.	1 to 4 fl. dr.
Tritur. elaterini...........	8 to 30 mGm.	⅛ to ½ gr.
Urethan.	0.120 to 2 Gm.	2 to 30 gr.
Ustilago, fl. extr...	1 to 4 C. c.	15 to 60 min.
Uva Ursi, fl. extr...........	2 to 4 C. c.	30 to 60 gr.
Valeriana................	2 to 4 Gm	30 to 60 gr.
abstr.................	1 to 2 Gm	15 to 30 gr.
extr	0.300 to 1 Gm	5 to 15 gr.
fl. extr................	2 to 4 C. c.	30 to 60 min.
tinct.................	4 to 8 C. c.	1 to 2 fl. dr.
" ammon	4 to 8 C. c.	1 to 2 fl. dr.
Veratrina................	1 to 6 mGm	1/60 to 1/10 gr.
Veratrum Vir., abstr........	50 to 250 mGm	1 to 4 gr.
extr.................	20 to 60 mGm	⅓ to 1 gr.
fl. extr	0.10 to 0.50 C. c.	1 to 8 min.
tinct..................	0.20 to 1 C. c.	3 to 15 min.
Viburnum, fl. extr.........	4 to 8 C. c.	1 to 2 fl. dr.
Vina, see drugs		
Xanthoxylum, fl. extr.......	1 to 2 C. c.	15 to 30 min.
Zingiber.................	0.500 to 2 Gm	8 to 30 gr.

REMEDIES.	Single Adult Dose.	
	Metric Weights and Measures.	*Old Apothecaries' Weights and Measures.*
Zingiber, fl. extr............	0.50 to 2 C. c.	8 to 30 min.
oleores................	60 to 200 mGm	1 to 3 gr.
tinct.	1 to 4 C. c.	15 to 60 min.
Zinci acet.....	50 to 100 mGm	1 to 2 gr.
brom................	30 to 100 mGm	$\frac{1}{2}$ to 2 gr.
iodid....	30 to 100 mGm	$\frac{1}{2}$ to 2 gr.
oxid.................	60 to 600 mGm	1 to 10 gr.
phosphid........... ..	5 to 10 mGm	$\frac{1}{12}$ to $\frac{1}{6}$ gr.
sulphas, emetic.........	1 to 2 Gm	15 to 30 gr.
valer.................	60 to 400 mGm	1 to 6 gr.

PART IV.

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PHARMACY.

PART IV.

PHARMACY.

CHAPTER LXXVI.

1349. The nature and sources of **heat** have been discussed in Chapter XV of Part I. Thermometry, the distribution of heat, the expansion of bod·ies under the influence of heat, and the relation of heat to the three states of aggregation of matter were sufficiently treated of in Chapters XV to XX, inclusive. The student is advised to again refer to those chapters at this stage of his progress.

1350. Among the **useful effects and applications of heat** in pharmaceutical operations are these: 1, to dry drugs, chemicals and pharmaceutical preparations; 2, to aid the solution of solids; 3, to facilitate the extraction of the soluble constituents of drugs by digestion or decoction; 4, to remove albumin from solutions of extractive by coagulation; 5, to destroy ferments; 6, to hasten evaporation; 7, to vaporize substances in distillation and sublimation; 8, to accomplish fusion; 9, to effect calcination; 10, to induce chemical reaction.

1351. Damaging effects of heat.—Heat is liable to produce damaging effects upon drugs, chemicals and pharmaceutical preparations under certain conditions. In the presence of moisture, heat may induce discoloration, mould, fermentation or putrefaction, in organic drugs or preparations containing gum, pectin, starch, sugar, albumin and various other constituents. Heat causes chemical changes in many organic compounds,

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such as alkaloids and glucosides, and may even entirely destroy sensitive constituents of organic drugs. Valuable volatile constituents are dissipated by exposure to heat. In the extraction of drugs with watery menstrua, by the aid of heat, starchy matter, which is wholly inert and therefore objectionable, may be dissolved out. Heat expels water of crystallization, causing certain salts to effloresce. Various other unfavorable effects are produced by temperatures not much above moderate heat. Higher temperatures are of course correspondingly destructive.

1352. **Fuel.**—Substances of organic origin which are comparatively readily ignited, burn rapidly and produce a large amount and high degree of heat, are used as fuel. These substances may be either solid, liquid or gaseous. Their principal constituent elements are C and H. To be available as fuel, they must of course be obtainable in sufficient quantities at moderate cost.

The products of the combustion (667) of fuel must be gaseous, little, if any, solid residue remaining.

1353. **The amount of heat** produced by the combustion of any particular kind of fuel is constant without reference to the method of combustion (or oxidation)—whether the fuel be burnt with oxygen, air, or a metallic oxide.

1354. **The intensity of heat,** or the temperature (314) produced by the combustion of any given kind of fuel, depends upon the rapidity with which the fuel is oxidized.

1355. Among the **solid fuels** are wood, charcoal, anthracite, coke, and soft coal.

Among the **liquid fuels** are coal oil and its products (particularly gasolin), fixed oils and alcohol.

Among **gaseous fuels** are the gaseous hydro carbons, of which the common coal gas is most familiar; "natural gas," which is also composed of hydro carbons (mainly marsh gas), affords more intense heat than the artificial gas. Fuel gas, which is hydrogen mixed with carbon monoxide (produced by the decomposition of water by passing steam over coal heated to an intense temperature) (676), is even better than natural gas; and hydrogen, as already stated elsewhere (670), produces in its decomposition the highest temperature obtainable.

1356. The quantity of heat obtainable from the perfect combustion of any particular kind of fuel is expressed in "heat units" or thermal units (335).

The following table gives the heat units obtainable from the most important fuels:

		Heat Units.	Water Evaporated.
Hydrogen.........	Burnt to water............	34,462	62.66
Carbon..........	" to carbon dioxide....	8,080	14.69
"	" carbon monoxide...	2,474	4.50
Marsh gas........		14,675	26.68
Olefiant gas.......		11,849	21.55
Crude petroleum...	" to carbon dioxide	10,190	18.53
Wax.	and water	10,496	19.04
Tallow..........		9,000	16.37
Alcohol..........		7,183	13.06
Carbon monoxide..	" carbon dioxide......	2,403	4.37

It will be observed from the foregoing table that the greatest amount of heat is produced by fuels containing the greatest proportion of hydrogen; but the maximum amount of heat which might theoretically be obtained is never attained practically, because the combustion is never complete when solid fuel is used; seldom when liquid fuel is employed; and not always even when the fuel is gaseous.

1357. The intensity of heat produced may be promoted by a full supply of oxygen or air, as by a good draft or the use of the bellows. The heat may also be intensified to some extent when solid fuel is used, by reducing the fuel to smaller pieces. Thus a pound of wood in the solid block and a pound of shavings of the same wood, produce the *same* amount of heat; but the shavings a more *intense* heat.

For many operations a steady, well-sustained heat is necessary. Hard coal is the best fuel to this end.

1358. Various kinds of **heating apparatus** employed for pharmaceutical purposes must of course depend upon two things — the kind of fuel employed and the uses to which the apparatus is to be put. It is not the purpose of this elementary work to describe such apparatus. We will only mention that in chemical manufacturing establishments and in operating upon large quantities of material, open *furnace* fires are often used; *stoves* of various patterns are also extensively used for pharmaceutical purposes; and that for most of the ordinary purposes of the pharmacist, *gas stoves* and *burners* are the most serviceable

wherever gas can be had, whilst, where gas is not obtainable, *gasolin stoves* and *burners*, and *spirit lamps* are the best.

1359. Steam heat, which is extensively employed in manufacturing establishments, is so effective because of the large amount of latent heat of steam and further, because of the fact that the temperature of steam does not exceed 100° C. (212° F.), except when under pressure. The steam is applied either by means of coil submerged in the liquids to be heated, or by means of steam-jackets. By a steam-jacket is meant the space between the double shell of a kettle or pan, there being a larger shell rivited to the bottom of the vessel, so that steam can be introduced between the two shells.

Hot water coil is also sometimes the best means of keeping vessels and their contents warm in certain special operations, as, for instance: in coating pills, etc.

1360. Among the **gas burners,** of which there is an almost infinite variety, some afford a large flame which may be applied to a considerable surface, and are, at the same time, furnished with supports for the vessels to be heated; while others give a

Fig. 87. Spirit lamp, with support for dishes.

narrow or pointed flame. Of the latter kind the Bunsen burner is the most effective. It simply consists of two tubes, the larger of which is about four inches long and carries the mixture of gas and air which is ignited at the top of this tube, the gas being supplied near the foot of and inside the larger tube by a very small tube with a pin-hole orifice. An adjustable valve is placed at the foot of and around the larger tube, but below the top of the small, narrow tube, and through this valve the air enters. If the amount of air supplied through this valve is sufficient for the complete combustion of the gas which issues into the tube, the flame produced at the top is bluish and affords intense heat, whereas if the valve is partly or entirely closed, so that the supply of air is insufficient, the flame will be yellow, smoky and luminous, and will not afford as high a temperature.

The heat is most intense a little distance above the top of the tube or just below the middle of the flame.

To prevent the dissipation of a part of the heat produced, jackets or chimneys may be placed over or around the burner.

Sometimes two or more burners are combined for the purpose of producing a greater quantity of heat.

Several varieties of gas burners are shown in figures 88 to 94.
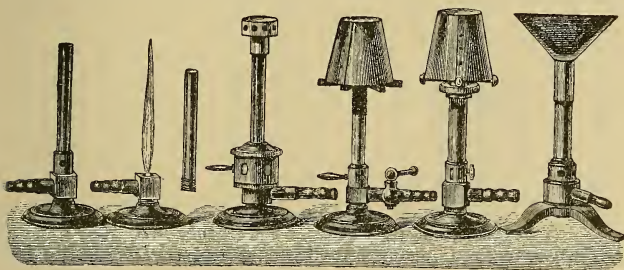
Bunsen burners.   Figs. 88 to 94.

1361.   Coal-oil and gasoline stoves are of various sizes, from the kitchen range down to a small lamp are now manufactured, which are smokeless, nearly odorless, and afford very high temperatures.

1362.   The **spirit lamp** is by far the most cleanly and generally useful small heating apparatus for the laboratory or the dispensing counter.   It affords high temperatures without smoke, soot, or any disagreeable odor; and if the wick of the spirit lamp consist of loosely twisted cotton yarn, it can be spread so as to afford a flame of large diameter if desirable.

1363.   For the **control** and **distribution** of the heat, various devices are employed.   One of these consists simply of *wire gauze* through which flame does not pass, so that when a gas burner is used the gas may be lighted either above or below the wire cloth, while at the same time the gas and its flame is

spread over a greater surface. This wire gauze may at the same time serve for a support for flasks, beakers and other vessels. (See Fig. 95).
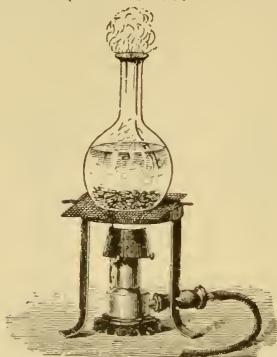
Fig. 95.

1364. The sand-bath consists simply of an iron dish containing sand, and is also used for the purpose of distributing heat more evenly. It may be deep, so that flasks and retorts, when placed in it, may be entirely surrounded by the hot sand; or it may be shallow, so that flasks, beakers or dishes placed in the sand are heated only over the bottom and can at the same time be raised, the sand being allowed to run down under them for the purpose of immediately checking too great intensity of heat.
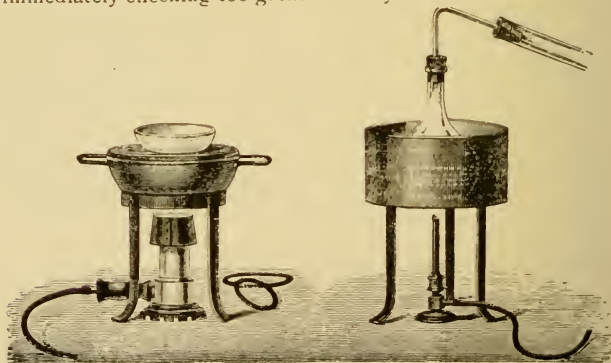
Fig. 96 and 97. Water-baths in use.

1365. The water-bath (Figs. 96 and 97) is a round vessel of copper or other suitable material in which water may be

heated to any required temperature up to its boiling point. Vessels to be heated by means of the water-bath are placed on top and serve as covers. The water-bath should be only about two-thirds full, and the dishes placed over it should not fit so closely as not to permit the escape of the steam generated when the water is boiling. As the boiling-point of the water is constant, it follows that the dish and contents placed over the water-bath can not be heated any higher than just below that temperature.

1365. Glycerin-baths, oil-baths and **solution-baths** are also useful, each affording high temperatures.

The advantage in using these several kinds of baths, except the sand-bath, is not merely to distribute the heat, but also to limit its intensity. Thus, while the water-bath affords a temperature not exceeding 90° to 96° C., the glycerin and oil baths impart a heat not exceeding about 200°C., and the saturated solutions of salt afford various maximum temperatures, according to their character (394).

1366. The following table of the **effects of certain temperatures** will be found convenient for reference:

Effects of Certain Temperatures.

	C.	*F.*
Freezing point of water......	0.°	+32.°
Maximum density of water.......	+4.°	39.°2
Standard temperature for sp. gr..................	15.°	59°
Common room temperature, about................	20.° to 22.°	68.° to 71.°6
Fermentation active at about.....................	25.°	77.°
"Gentle heat," U. S. P.........................	32.° to 38.°	90.° to 100.°
Blood heat......................................	37.°	98.°
Boiling point of stronger ether...................	37.°	98°6
Starch forms paste with water at about............	60.°	140.°
Albumen coagulates at about	60.°	140.°
Boiling point of alcohol.........................	78.°	172.°4
Water-bath heat, about.........................	90.°	194.°
Boiling point of water..........................	100.°	212.°
Oil-bath heat, about...........	200.°	392.°
Glycerin-bath heat, about.......................	200.°	392.°

Dry Processes Requiring Heat.

1367. Desiccation means simply the drying of drugs and chemicals not involving their decomposition nor the loss of water of crystallization.

1368. Fusion (376) is simply the liquefaction of solids by the aid of heat, which is frequently accomplished either for the purpose of inducing chemical reaction, as in the preparation of the iodides of arsenic and sulphur, or to render an intimate inter-mixture of several substances possible, as in making ointments, plasters, etc.

1369. Exsiccation means the expulsion of water of crystal-lization (120 to 124) from crystallized salts by the aid of heat. Among the pharmacopœial preparations which are exsiccated or dried, are sulphate of iron, alum, carbonate of sodium, and others.

1370. Ignition is a term used to designate the heating of any solid or mixture of solids to a very high temperature in contact with the air for the purpose of causing chemical changes, the product sought being a fixed residue.

When the ignition includes rapid oxidation (1003) with the aid of some oxidizing agent (1006) as with a nitrate, but without explosion, the process is sometimes called *deflagration*. This is illustrated in the preparation of sodium arsenate (1005).

The ignition is called *incineration* when organic substances are burnt to ashes, the product sought being one or more of the constituents of the ash.

When organic substances are strongly heated with a very limited supply of oxygen or air, so that a charred residue remains, consisting largely or entirely of carbon, the ignition is called *carbonization*.

The term *torrefaction* has been used to designate the partial decomposi-tion of certain organic drugs by dry heat for the purpose of destroying some of their constituents without injuring others. Torrefied rhubarb retains the astringent effect, but does not have the cathartic properties of rhubarb. The author has never seen torrefied rhubarb, and is not aware that it is ever used.

1371. Oxidation and reduction by means of dry heat have been referred to in Chapter LVIII of Part II.

The term *roasting* is sometimes applied to the ignition of metallic sulphides and certain other inorganic compounds in free access of air for the purpose of causing their oxidation. Thus antimony sulphide may be roasted until both the antimony and the sulphur are oxidized, the sulphur forming the gas SO_2,

which passes into the air, and the antimony forming Sb_2O_3, which is the product sought.

1372. The definition of the process of calcination as usually given would seem to include many different chemical decompositions by dry heat, including oxidation by roasting, the conversion of sulphate or oxalate of iron into ferric oxide, the incineration of bone to make *bone ash*, the conversion of sodium phosphate into pyro-phosphate, mercury nitrate to mercuric oxide, etc. The usual definition is: "the process of separating volatile substances from fixed inorganic matter by the application of heat without fusion." Others again say that it is "strongly heating inorganic *crystalline* substances with a view to the removal of water, CO_2, or other volatile constituent."

But the term calcination is derived from the word *calx*, which means lime, and has reference to the process by which lime-stone is converted into lime (777). The use of the term calcination should, therefore, be limited accordingly, and the true definition of

Calcination is the conversion of metallic carbonates into metallic oxides by the influence of strong heat.

The product is always the fixed residue, which is an oxide, while the bye-product is either CO_2 alone, or CO_2 and water.

The most familiar examples of calcination are furnished by the preparation of lime, magnesia, and zinc oxide.

1373. Destructive distillation or **dry distillation** is the decomposition of solid substances by heat, the solids being contained in retorts or cylinders connected with receivers in such a manner that the volatile products of the decomposition can be collected. Thus, in the manufacture of acetic acid, billets of oak wood are enclosed in large iron cylinders and there heated, air being excluded so that the wood, instead of undergoing combustion, is decomposed by the high temperature with the formation of acetic acid besides very many other products. The acetic acid thus produced vaporizes, distills over, and is collected in the receiver as pyroligneous acid, which is simply impure acetic acid.

1374. Sublimation (377 and 406) as a pharmaceutical process is the vaporization of solids by heat under such conditions that the vapor is collected and condensed back to the solid state. The object of sublimation is to separate volatile from fixed sub-

stances, and it may either be one of the steps in the process of production of a volatile solid, as in the preparation of calomel and corrosive sublimate (794), and in the separation of benzoic acid from benzoin, in which that acid is contained naturally; or the sublimation may be a method of freeing a volatile substance from fixed impurities, as in the resublimation of camphor and iodine.

CHAPTER LXXVII.

COMMINUTION.

1375. The **disintegration** or **comminution** of solids is a necessary preparatory step in many pharmaceutical operations.

For the preparation of mixed *species* (1536) most of the crude drugs which enter into them are required to be cut or crushed, and cut or crushed drugs are also frequently employed for making infusions, decoctions, solid extracts, certain tinctures, wines, vinegars and syrups, etc.

Solids occurring in large masses or pieces, or in large crystals, must be reduced to smaller particles for purposes of extraction or to hasten solution.

1376. Among the various kinds of comminution or mechanical division are cutting, slicing, chopping, rasping, grating, contusion, grinding, trituration, levigation, elutriation, granulation, etc. Nearly all of these terms are self-explanatory.

1377. For **cutting, slicing** and **chopping** plant drugs it is necessary to employ sharp edge-tools to avoid tearing or crushing and the consequent formation of powder. In many cases it is desirable to produce clean-cut, uniform pieces free from powder. Starchy roots and drugs of friable texture, as, for instance, althæa and rhubarb, when required for extraction

by maceration or digestion for the preparation of infusions or syrups, should not be cut with dull knives producing ragged fragments or shreds mixed with loosened starch granules, which render the product unclear.

Pruning knives and shears, the ordinary tobacco cutter and good hash knives are, when well-sharpened, useful instruments for cutting plant drugs.

1378. Rasping and **grating** are applicable in a few cases, and are accomplished by means of large, coarse, half-round rasp and the ordinary graters used for culinary purposes.

1379. Crushing and **grinding,** producing very coarse powder, is effected by means of iron hand-mills. These drug mills are constructed upon the same general principles as the large coffee mills of the grocery stores, and are capable of reducing a great variety of drugs to a moderate degree of disintegration. The drug to be passed through the iron drug-mill must first be broken or chopped if in pieces too large to pass between the grinding plates without difficulty, and it is frequently necessary to pass the same lot of drug through the mill several times in succession, setting the mill finer each time, before the powder is of the required degree of fineness. But fine powders can not be made by the use of the hand-mill alone (1382).

1380. Drug mills driven by steam-power, such as Mead's disintegrator, grinding mills of iron, roller mills, burr mills, chasers, pot mills, etc., which are used only by drug millers and manufacturers, will not be described here.

1381. The iron mortar and pestle are extremely useful to the pharmacist who desires to prepare his own powdered drugs as far as practicable, for percolation and for other purposes.

The iron mortar, in order to be of great practical use, should be of at least six gallons' capacity. It must have a solid, heavy, iron pestle of perfect form and size to match the mortar (1384), and the grinding surfaces must be polished by powdering emery or sand until perfectly clean and lustrous. The top of the

mortar should be flaring.

Fig 98.

It is much deeper than mortars intended for any other use, except that commonly employed for preparing mixture of almond. (Fig. 98.)

As the iron mortar is very heavy, and great force is expended in contusion (1383), it must stand firmly upon a block or pillar, resting not upon the floor but on the ground.

1382. With an iron mortar of from six to eight gallons capacity it is not difficult to make quite fine powders of nearly all kinds of drugs, if the quantity put into the mortar at one time be not greater than just enough to cover the bottom. When a plant drug is to be reduced to fine powder it is generally best to run it through the iron mill first, and then to powder it in the iron mortar.

1383. To break, bruise, crush or powder a substance in a mortar by means of blows with the pestle is called *contusion*.

The directions in which the force is applied must depend upon the nature of the substance operated upon, but when *pulverization* is the object the blows must be accompanied by a grinding and sliding motion.

1384. Any mortar must have a perfect, smooth, regular, spherically concave bottom. It must be of a sufficiently hard material of uniform and compact texture, neither porous, slippery, nor brittle. The convex surface of the *head* of the pestle

Fig. 99.
A small powder mortar.

should be of perfect form—neither flattened, pointed, nor irregular—and of a somewhat smaller radius than the curve of the grinding surface of the mortar, so that, while there can be but one point of contact, the divergence of the surrounding interval between mortar and pestle will be quite gradual. Fig. 99 shows a proper relation between the grinding surfaces of mortar and pestle. In mortars used specially for triturating (1385 and 1386) powders, the head of the pestle may be somewhat more flattened.

1385. **Trituration** is the grinding produced in the mortar by a rotary motion of the pestle accompanied by pressure. The pestle is grasped firmly, the whole hand being used for the purpose.

Small amounts of brittle solids can be reduced to fine powder by trituration, and some substances which are not brittle can be powdered in the same manner, provided their disintegration is aided by the addition of a small quantity of some unobjectionable volatile solvent, as when camphor is powdered by trituration with the aid of a little alcohol or ether, or when lactucarium is powdered with the aid of chloroform, or iodoform with the addition of ether.

Certain soft or tough solids may be powdered by trituration with hard substances, as when vanilla or fresh orange peel is rubbed to powder with sugar, or when abstracts and triturations are made with milk sugar.

1386. Trituration is also employed for mixing powders, or to powder and mix substances at the same time. For these purposes the trituration is best performed by moving the pestle in circles, beginning near the center of the mortar, enlarging the circles toward the circumference, and returning toward the center again by gradually diminishing the diameter of the circles described.

1387. When dry substances only, already in fine powder, are to be mixed by trituration, pressure is unnecessary, and when the substances triturated are liable to adhere to the mortar and pestle, as in the case with resins, gumresins, camphor, alkaloids, and several other kinds of dry solids, no pressure should be applied.

1388. Mortars and pestles are also used for *massing* the ingredients in the preparation of masses, troches, and pills, for preparing small quantities of *solutions*, making liquid *mixtures* and *emulsions*, in the preparation of certain oint-

Figs. 100 to 102. Pill mortars.

ments, cerates, and suppositories, and for many other purposes.

Various kinds of mortars are employed. Shallow mortars of large diameter are the best for mixing powders and ointments;

small, rather deep strong mortars are used for making pill masses; larger and still deeper lipped mortars for making liquid mixtures and emulsions, etc.

Mortars and pestles are made of wedgewood composition, porcelain, glass, and various other materials. Porcelain mortars are either glazed or unglazed, each kind being useful for its own special purposes.

Figs. 103 and 104. Mixture mortar and pestle.

Pill mortars of iron are not uncommon.

Fig. 98 to 104 represent different kinds of mortars.

1389 The **spatula** is as indispensable in pharmacy as the mortar and pestle. They are made of steel, platinum, silver and horn. Steel spatulas are the most useful because flexible and elastic; but the other materials are preferred in operating with substances which attack steel, as is the case with many chemicals.

Spatulas are used not only to transfer substances from the shop bottle to the balance pan, or from one vessel to another, but to scrape off or scrape together substances adhering to mortar or pestle for the purpose of rendering possible the uniformly intimate intermixture of the ingredients.

In the preparation of some ointments, and even some compound powders, the spatula and slab may be preferable to the mortar and pestle.

1390 **Levigation** is the trituration of substances to a fine state of division by means of a slab and muller, as paints are sometimes mixed, a liquid of some kind being added to the solid matter which is to be thus rubbed fine, so as to produce a soft paste. Water, alcohol and oil are used for this purpose. Sometimes the levigation also involves purification, as when an insoluble solid is triturated with water not only to reduce it to a finer powder but also to wash out any water-soluble impurities.

1391. **Elutriation** is a process sometimes employed to separate fine

powder from coarse particles. It is applicable only to inorganic substances heavier than water and insoluble in that liquid. It consists in agitating the powder with a large volume of water, desisting while the coarser particles subside, and decanting into another vessel, the liquid holding the finer powder in suspension, after which this powder is allowed to deposit on the bottom and is then collected.

Levigation usually precedes elutriation, and the substance which is to be thus powdered and sifted is subjected to these two processes alternately until the requisite amount of fine powder has been obtained. The product may be made extremely fine. Prepared chalk and purified antimony sulphide are elutriated.

1392. The **granulation** of salts is effected by several different methods, which will be described later (1489).

1393. The **powders** produced by all of these several methods are far from uniform. The greatest attainable uniformity of division is probably attained by trituration and by levigation, whilst powders obtained by contusion and by grinding consist of particles of various sizes, some of them several times as large as others.

To regulate this want of uniformity as far as practicable the coarser particles are separated by means of sieves, the meshes of which are small enough not to admit of their passage through the sieve cloth with the finer particles. But this method can not, in the nature of things, produce a uniform degree of fineness in the powder obtained, for every particle of the drug can not be subjected to precisely the same treatment, and plant drugs are not of exactly the same texture throughout, so that the more friable tissues are not only powdered first but also reduced to a finer state of division than the tougher tissues. Thus a powder made to pass through a sieve of 40 meshes to the linear inch may consist of about equal proportions of moderately coarse, moderately fine, fine, and very fine powder.

1394. This inequality of size of the particles of powder can not be remedied by sifting off the finest, as by passing the powder first through a sieve of 40 meshes to the inch and then through another of 50 meshes to the inch, for the obvious reason that it is altogether impracticable to reject the bulk of the drug,

and also for the still more potent reason that it frequently happens that the finer powder consists of the most active portions of the drug, the tougher portions, which are last reduced to powder and form coarser particles, containing a greater proportion of woody fibre or other inert matter.

1395. From what has been stated in the preceding paragraph it will be readily understood that whenever a drug is powdered two conditions must be fulfilled in order to obtain a proper product, viz.: 1. The entire quantity put in the mill or mortar must be reduced to powder, and 2, the powder obtained must be well mixed before any portion of the product is taken away for use.

1396. Comparatively coarse powders are employed for making extracts, such as infusions, tinctures, fluid extracts, solid extracts, abstracts, etc., while very fine powders are necessary for the preparation of compound powders, pills, troches, etc. Powders administered as such, or entering into medicines as such, can not be too fine.

1397. The **relative fineness** of **powders** is indicated in the Pharmacopœia by means of numbers referring to the meshes in the sieve cloth. Thus a powder which passes through a sieve cloth having 80 meshes to each linear inch is called a No. 80 powder; one that passes through a sieve cloth of 40 meshes to the linear inch is a No. 40 powder, etc.

No. 80 powder is called "very fine"; No. 60 powder is referred to as "fine"; No. 50 is "moderately fine"; No. 40 "moderately coarse"; and No. 20 is "coarse" powder.

1398. The **sieves** used by pharmacists for ordinary powders are usually made of brass wire cloth if coarse, or of silk if fine. The sieve frames are generally circular. Sometimes they are provided with covers above and beneath to prevent the dust from rising, and they are then called "drum sieves."

1399. **Dusted powders** are produced by chaser mills, and are so called because they are so fine as to rise like dust with the currents of air created by the revolutions of the mill stones, and are deposited on the floor outside of the tall iron cylinder surrounding the stones, or on shelves in the mill box.

1400. Very friable masses, such as magnesium carbonate and bismuth subnitrate, are powdered by simply rubbing them gently against the cloth in a sieve.

1401. Colored substances become lighter in color when powdered, and their color grows lighter as the powder gets finer.

CHAPTER LXXVIII.

SOLUTION IN PHARMACY.

1402. In Part I, Chap. X, a brief account was given of the nature of solution, the difference between simple and chemical solution, the miscibility of liquids, solvents and solubility, etc. The student should here refer again to that chapter.

1403. **To dissolve solids** most expeditiously they are first *crushed or powdered*, so that the surface exposed to the action of the solvent may be increased.

Another effective means of facilitating solution is *agitation*. Stirring or shaking the solvent together with the substance which is to be dissolved insures more rapid solution because it brings each portion of the one in contact with fresh portions of the other. If a solid substance resting on the bottom of a vessel be covered with a sufficient amount of the proper solvent, and the solution allowed to proceed at perfect rest, the solid would soon be enveloped in or covered up by the solution first formed at the surface of contact, and this solution, interposing between the solid and the remaining portion of the liquid, would retard the process, but agitation would at once distribute the dissolved matter throughout the whole body of liquid.

1404. To bring the solid in contact with new portions of solvent successively the solid may be placed in a perforated dish or basket, or in a loose bag, or on a colander or perforated diaphragm, just below the surface of the solvent, so that the solution may descend to the bottom of the vessel as fast as it is

formed, other portions of liquid at once occupying its place in contact with the solid. This is called **circulatory displacement.**

1405. That the application of *heat* generally hastens the solution of solids will be easily understood from the fact that the solid must take up latent heat (311) in order to become liquefied (385).

A warm or hot solvent generally dissolves a larger quantity of solid matter, and dissolves it more rapidly than a cold solvent.

Thus 200 ounces of boiling water will hold 100 ounces of potassium chlorate in solution; but when this solution is allowed to cool to the ordinary room temperature, only about 12 ounces of the salt will remain in the liquid, 88 ounces having crystallized out as the temperature gradually decreased.

1406. But heat does not invariably aid the solution of solids, for common salt (sodium chloride) does not dissolve better in hot water than in cold, and the same is true of calcium hydrate, acacia, and a limited number of other water-soluble solids. Nor is the difference between the solubility of a solid in a hot solvent and its solubility in the same solvent at a lower temperature generally as great as in the case of potassium chlorate in water as described in the foregoing lines.

1407. Maximum solubility.—Experimental results with numerous bodies would seem to indicate that each substance is soluble in the greatest proportion in any given solvent at some fixed temperature being soluble in less amount either above or below that temperature. A most striking example is furnished by sodium sulphate, which reaches its maximum solubility at 15. 6 C. (60° F), the solubility decreasing on either side of that point so that at 100° C. (212° F.) the solubility is nearly the same as at 0.° C. (32° F.)

1408. A solution of one substance may be an effective solvent for another substance (188). Thus, aloes is entirely soluble in four times its weight of boiling water, because some of the constituents of the aloes which are insoluble in pure water are nevertheless soluble in a strong water solution of the other constituents of the drug; but this strong solution of the whole of the aloes in four times its weight of boiling water can not be diluted by the addition of more water, hot or cold, without

becoming turbid, and if a sufficient quantity of water be added the greater part of the dissolved matter will separate.

1409. **Compound solution** is a term often employed. It is synonymous with the expression *chemical solution* (190). At the same time the title *compound solution* is also used to designate pharmaceutical solutions containing more than one ingredient aside from the solvent, as for instance the "compound solution of iodine" containing iodine and potassium iodide.

1410. In paragraph 188 a definition was given of a **saturated solution.** We will now add that a solution of a solid, saturated at a given temperature, is not saturated at a higher temperature, and a solution of gas saturated at a given temperature is no longer saturated when the temperature is lowered.

1411. But we may have a **super-saturated solution** in many cases, when the solution of a solid is made saturated at any temperature and then slowly cooled a few degrees lower, no separation resulting. The solution thus formed may contain or retain a larger quantity of dissolved matter than it would have been possible to dissolve in the solvent except at a higher temperature than the solution now has.

A super-saturated solution of sodium sulphate may be made which will remain free from deposited salt for an indefinite period if kept at absolute rest, but which contains so large an amount of the salt in solution that when it is suddenly agitated, or when a crystal is dropped into it, the entire solution solidifies into a crystalline salt mass. But this is an exceptional case.

1412. **Partial solution** is of very frequent occurrence in pharmaceutical operations.

Mixtures of solid substances, or drugs of a heterogeneous structure or composition, such as the plant drugs, are generally only *partially* soluble in any one solvent. Thus a gum-resin yields its resin to alcohol but not its gum, whereas it yields to water its gum but not its resin. Roots, barks, leaves and other plant parts yield different substances to different solvents, so that both the composition and the amount of the extract obtained differ according to the menstruum employed.

1413. When mixtures of soluble and insoluble inorganic substances are separated from each other by the solution of the soluble contents, this process is called lixiviation. The most familiar illustration of lixiviation is the extraction of the potassium carbonate from wood ashes by treating the ashes with water.

1414. Fractional solution.—The application of different solvents, one after the other, for the purpose of separating substances of different solubilities, is sometimes called fractional solution. The two or more solvents used may differ only in temperature, or in power.

1415. To facilitate the **solution of gases** in water, cold and pressure are applied.

Cold water dissolves more chlorine than warm water; to charge "carbonic acid water" with as large a quantity of the gas CO_2 as practicable, the water must be chilled and the gas must be forced into a strong "fountain" where it is agitated with the water, the amount of gas dissolved being in direct ratio to the pressure imposed. When the pressure is removed by opening the "fountain," CO_2 rushes out of the solution. If the carbonic acid water be heated all of the "carbonic acid gas" will be expelled.

1416. The **solution of liquids** in other liquids is a common phenomenon. Many liquids are miscible with each other. A mixture of glycerine and water is as truly a solution as the not more homogeneous liquid obtained by dissolving sugar in water.

Again, some liquids are soluble in their proper solvents only to a limited extent, as is the case with the volatile oils in reference to alcohol.

Finally, we can dissolve a limited quantity of ether in water, and *per contra* a limited quantity of water in ether, and these two different solutions do not mix with each other.

A saturated solution of carbolic acid in water is not miscible with a saturated solution of water in carbolic acid.

1417. The most important **solvents** used in pharmaceutical operations are: water, alcohol, ether, chloroform, glycerin, volatile oils, carbon disulphide, fixed oils, and solutions of the acids and alkalies.

1418. Water as a Solvent.—Water is the most valuable of the *simple solvents.* Its solvent powers are great, it is itself entirely neutral, and it is universally present and easily obtainable in a state of purity.

1419. Water-soluble Substances.—Of the numerous substances which are more or less soluble in water, many are necessary to the existence of plants and animals, and others are of the utmost importance in the arts and manufactures.

Among the water-soluble *organic substances* are: Sugar, gum, the normal albuminoids, and many organic acids. In addition to these groups, an infinite variety of complex organic bodies, as the tannins, a great number of glucosides and other neutral principles, and most of the alkaloidal salts, are also water-soluble.

Among the water-soluble *inorganic substances* are: the alkalies, the stronger acids, and most of the salts. Thus the compounds of potassium and sodium are with but few exceptions readily soluble in water; the nitrates are soluble, except the normal nitrates of mercury and bismuth, which are decomposed by water, and the basic nitrates of the same metals which are insoluble; the normal acetates are all soluble; the chlorides are soluble, except calomel and the chloride of silver; and many iodides, bromides, cyanides, sulphates, etc.

1420. Substances insoluble in water.—Among the *organic substances* insoluble in water are: Cellulose, normal starch, coagulated albuminoids, resins and fixed oils; the volatile oils are sparingly soluble; and free alkaloids are generally very sparingly soluble.

The *inorganic substances* insoluble in water include all the solid, non-metallic elements, the metals, the oxides, sulphides, carbonates, phosphates and oleates of the heavy metals, and a number of other compounds.

1421. Liquores.—The "liquores" or "solutions" of the Pharmacopœias of the United States, Great Britain and Germany, are aqueous solutions of non-volatile substances, mostly inorganic chemicals.

1422. Alcohol as a Solvent.—Alcohol ranks next to water as a simple solvent. It is indispensable in the arts and manufactures. Instead of being absolutely inactive, however, as water is, alcohol, when introduced into the body of man or animal, produces marked effects which greatly limit its usefulness.

1423. Alcohol-soluble Substances.—Alcohol dissolves resins, volatile oils, most of the free alkaloids, and many of the neutral proximate principles of plants.

It also dissolves the alkali-hydrates, some chlorides, iodine and a few other inorganic substances.

1424. Substances insoluble in alcohol.—Cellulose, gums, starch and albuminoids are insoluble in alcohol. All the fixed oils are insoluble in that liquid, except castor oil and croton oil. Alkaloidal salts are generally far less soluble in alcohol than in water.

Inorganic salts are mostly insoluble in alcohol.

1425. Ether as a Solvent.—Ether is an effective solvent for fixed oils and fats, which, as has already been stated, are insoluble in water, alcohol and glycerin. Ether also dissolves certain resins, volatile oils, alkaloids, and various other organic compounds. Inorganic substances are generally insoluble in ether, as are also cellulose, starch, gum, sugar, and albuminoids.

1426. Chloroform dissolves a great number of the alkaloids, and is also an effective solvent of fats and fixed oils, resins, and many other substances.

1427. Glycerin as a Solvent.—Glycerin dissolves a great variety of substances, both organic and inorganic. It is a specially effective solvent for tannin and organic tannin compounds.

1428. Menstrua.—A liquid used chiefly as a solvent, but also in part as a vehicle for medicinal substances is called a *menstruum*. The most common pharmaceutical menstrua are : water, alcohol and syrup.

1429. Among the pharmaceutical solutions are: the liquores, waters, mucilages, syrups, infusions, decoctions, spirits, tinctures, fluid extracts, wines and vinegars.

1430. Solutions are made in mortars, dishes, beakers, flasks, and various other vessels. When solids in a state of powder,
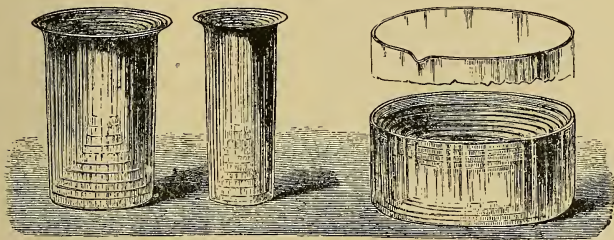
Figs. 105 to 107. Nests of beakers.

coarse or fine, are to be dissolved, beakers and flasks are probably the most convenient vessels for the purpose, especially the beakers (Figs. 105 to 107).

CHAPTER LXXIX.

FILTRATION AND OTHER METHODS OF CLARIFYING LIQUIDS.

1431. When solutions of solids are prepared it often happens that the product is unclear from the presence of particles of dust and other insoluble solids. Many liquid extracts, as infusions, tinctures, etc., and other liquids, may be turbid from suspended particles of solid matter. To separate these solid particles so as to render the liquid perfectly clear, the latter is passed through some porous filtering medium, such as unsized porous paper, or paper pulp, or glass wool, asbestos, powdered glass, magnesium carbonate, calcium phosphate, charcoal, etc. This process is called **filtration**, and the clear liquid thus obtained by it is called a *filtrate*, and the paper or other medium through which the filtration is effected is called a *filter*.

1432. Filter paper is the most convenient and effective filtering medium for almost all liquids not too viscous to be filtered through it.

There are several grades of filter paper, differing in color, purity, thickness, and porosity.

Gray filter paper is sufficiently free from iron to be useful for the filtration of many pharmaceutical liquids, as tinctures, waters, and oils, but not suitable for the filtration of solutions of chemicals, such as acids, alkalies, and salts.

White filter paper is always purer and sometimes absolutely free from iron and other impurities liable to be found in the gray paper. Chemical filter paper is manufactured at Grycksbo, in Sweden, which is in every way all that can be desired, leaving the least possible amount of ash when burnt. Solutions of chemicals, unless so corrosive as to attack the paper itself, can be freely filtered through good white filter paper without discoloration or contamination of the filtrate.

But for pharmaceutical purposes, coarse, thick, very porous, white filter paper, which can be safely used for all non-corrosive liquids, and which will at the same time admit of rather rapid filtration, is the best kind.

It may be had either in whole square sheets, or cut into round filters of various sizes ready for use. The latter kind is the most convenient, and at the same time the most economical, as its use involves no waste.

1433. Paper filters are either *plain* or plaited.

A plain or simple filter is made by first folding the round paper across the center once, and then folding the double half-circle thus formed, also in the center, this second fold being opened out again; then one flap or end of the half-circle is folded in the middle so that its edge coincides with the crease which divides the half-circle in two equal parts, and the other end or flap is folded *on the opposite side* also with its edge against the center crease. The paper as now folded is a quarter segment of the circle. The filter is now opened out, and will be found to be of three thicknesses of paper on two opposite sides, but of only one thickness of paper on the two other opposite sides, while the perfect cone formed by the open filter fits perfectly in a funnel of 60° angle.

Plain filters are used for collecting and washing precipitates, and often also for simple filtrations; but the filtration of large quantities of liquids through plain filters is too slow,

because this filter, when properly fitted into the funnel, lies close
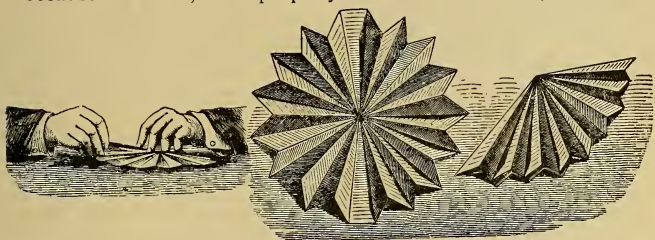
Figs. 108 to 110. Making a plaited filter.

to its sides all around so that the liquid can not pass through the
paper except at the apex.

Plaited filters are made as shown in Figs. 108 to 113, and are
preferred to the plain filter when rapid filtration is desirable, as
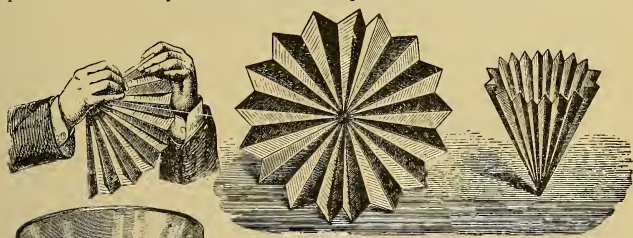
Figs. 111 to 113. Plaited filters.

Fig. 114. A perfect funnel.

the plaited filter leaves a number of chan-
nels between the paper and the funnel, per-
mitting the liquid to run off more freely.

1434. **Glass funnels** fit for all pur-
poses must have an angle of 60 degrees.
Such funnels are the only kind in which a
plain filter can be fitted snugly, and, there-
fore, no other funnels can be used for col-
lecting and washing precipitates, while
they are as good as any other funnels for
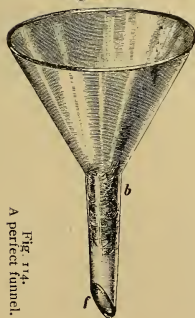
all other purposes. Funnels of other angles can be used for filtration with plaited filters. (See Figs. 118 and 119.)

A perfect funnel should also have a regular and well formed *throat*, and its *stem* should have a beveled end so that the liquid passing out of it will form one undivided stream. (See Figs. 114, 115 and 116).
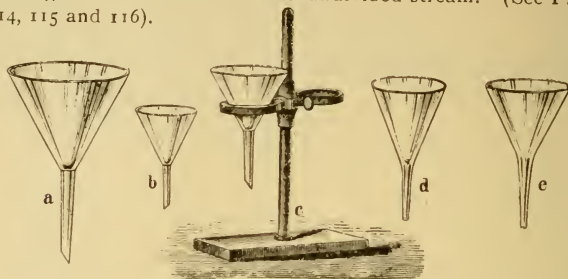
Figs. 115 to 119. Funnels and filter stand.

1435. The paper filter and funnel must fit each other; the upper edge of the filter should be about ¼ to ½ inch below the top of the funnel.

Fig. 120. Lamp stand and continuous filtration.

1436. **Filter stands** are shown in Figs. 117 and 120. The stand represented in Fig. 120 is also a *lamp stand*, but is commonly, although very improperly, called a "retort stand."

In filtration the funnel must be so placed that its stem is within the top of the vessel in which the filtrate is collected, and the end of the stem should touch one side of the receiving vessel so that the stream of liquid may run down that side to avoid spattering.

Fig. 120 also shows an inverted flask placed over the funnel to furnish a continuous flow of the liquid to be filtered, and the receiving vessel is a beaker.

1437. *Ribbed funnels* are sometimes used to render plaited filters unnecessary.

Filter baskets are also employed for the same purpose—to provide a passage for the liquid between the filter and the funnel. The filter basket is a funnel-shaped frame of wood, whalebone, or wire; it is placed in the funnel, and the filter in the basket.

Or glass rods, little strips of wood, etc., may be placed between the filter and the funnel.

1438. *Viscous liquids* do not easily pass through filter paper, and *some* thick liquids can not be filtered at all. But many viscous liquids which pass through the filter only with great difficulty when of the ordinary temperature can be readily filtered if warmed sufficiently.

Corrosive liquids must be filtered through glass, wool, coarsely powdered glass, asbestos, or sand, instead of paper.

1439. **Colation** or **straining** is the separation of solid particles from liquids by means of flannel, muslin, felt and other fabrics, cotton, tow, sponge, etc. It differs from filtration only in regard to the filtering media used, which do not always produce
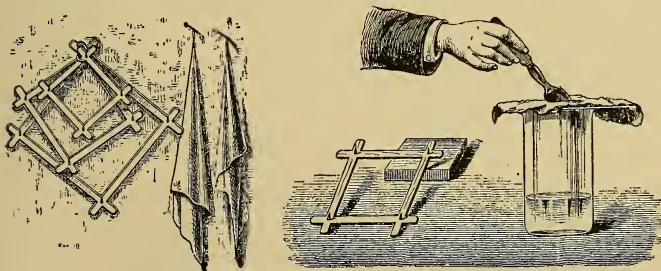
Figs. 121 to 123. Colation; straining cloths and frames.

as perfect results as filtration through paper. The liquid which passes through the *strainer* is called the **colature**. A colature is rarely as clear as a filtrate, and the clarification begun by colation is often finished by filtration.

A **tenaculum** is a square wooden frame for supporting straining cloths. Several such frames are shown in Figs. 121 to 125.
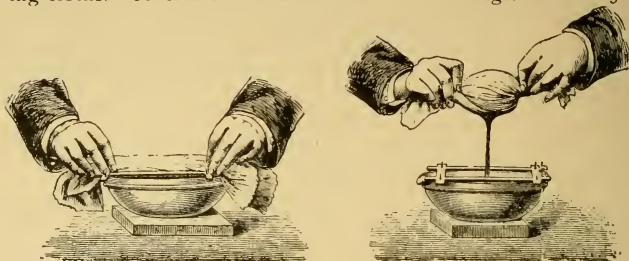
Figs. 124 and 125. Colation.

A *Hippocrates' sleeve* is a pointed straining bag. Such bags are made of cotton cloth or of flannel.

1440. Decantation.—In many cases the most convenient and effective method of clarifying liquids, especially when large quantities are operated upon, is to allow the liquid to stand at perfect rest a sufficient time to insure the *subsidence* of all the particles of solid matter which are suspended in it and make it unclear, and then to remove the *supernatant* clear liquid by *decantation*. Decantation is the process of carefully pouring off a liquid from a precipitate, a sediment, a mass of crystals, or any other substances from which it is desired to separate that liquid perfectly.
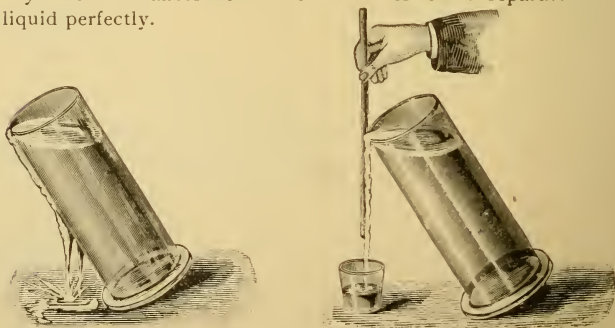
Figs. 126 and 127. Decantation, with and without the guiding rod.

To pour a liquid from one vessel to another without spilling is an art which every pharmacist must acquire. When the vessel containing the liquid is provided with a flaring top or with a lip and is not quite full, it is easy enough; but otherwise it
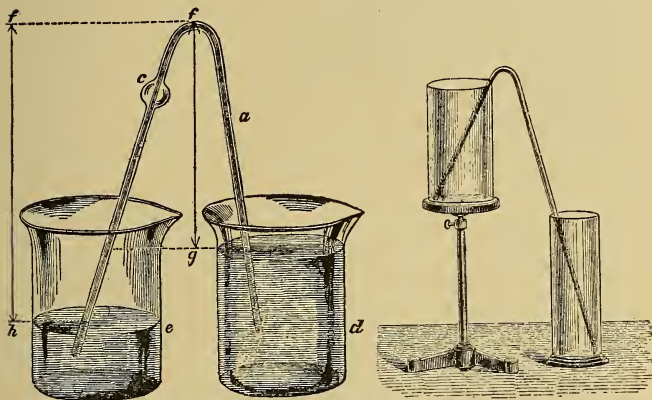
Figs. 128 and 129. Siphons of glass tubing.

is a feat which requires practice before it can be safely and well done. The use of the guiding rod helps; or the rim of the container may be greased.

Instead of *decanting* the liquid, the siphon may be used with great advantage (297).

1441. Pharmaceutical liquids, which it is possible to render as clear as the most transparent crystal, should never be in any other condition. Even the fixed oils and syrups of a drug store

Fig. 130. Rubber siphon.

should be filtered through paper as far as their nature permits.
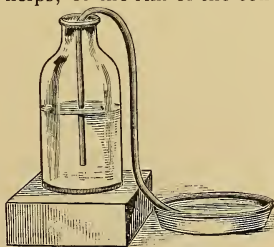
1442. There are several other methods of clarifying certain turbid or unclear liquids which will not pass through filter paper, or which can not be rendered clear by filtration, colation or subsidence and decantation.

Sometimes the *application of heat* is sufficient to cause the impurities to rise to the surface so that they can be skimmed off, or the diminished density of the liquid resulting from the increased temperature may render the subsidence of suspended solid matter possible.

When the unclearness of the liquid is due to tannin, the addition of a little *gelatin* precipitates the tannin and clarifies the liquid.

Albumen added to an unclear liquid frequently clarifies it on the application of heat sufficient to coagulate the albumen which then carries the suspended solid matter down with it. The white of one egg is usually sufficient for a gallon of liquid, and all the egg albumen added is of course removed again by the coagulation.

When the unclearness depends upon the presence of pectin or of albumin, and the liquid at the same time contains sugar, the clarification may be effected by *fermentation;* or, if the cloudiness is due to albumin alone, the liquid may clear up when heated to the temperature at which albumin coagulates.

1443. Insoluble solid matter which is held in suspension in a liquid, and which gradually descends to the bottom of the vessel in which the liquid is contained, constitutes, after its subsidence, what is called **sediment**.

1444. **Decolorization** and **deodorization** of organic substances in the liquid state is accomplished by filtration through charcoal. Sometimes vegetable charcoal is sufficient for this purpose, but animal charcoal is far more effective. Charcoal has the property of absorbing many coloring matters and odorous substances.

CHAPTER LXXX.

EVAPORATION, DISTILLATION, AND THE GENERATION AND SOLUTION OF GASES.

1445. In Chapter XX of Part I you read about the relation of heat to the three states of aggregation of matter, the lique-faction of solids by heat, and the vaporization of both solids and liquids. Now refer to that chapter again and refresh your memory concerning *fusion* and *melting points*, *fusible* and *refractory* bodies, *volatile* and *fixed* bodies, the *tension of vapors* (77 and 279), *evaporation, vaporization, ebullition, boiling points, distillation and sublimation* (1374).

1446. **Spontaneous evaporation** is the slow conversion of volatile substances into vapor at ordinary temperatures.

Evaporation is the comparatively rapid conversion of volatile bodies into vapor at temperatures below their respective boiling points.

Vaporization is the rapid conversion of substances into vapor at their respective boiling points.

1447. **Boiling** or **ebullition** is the bubbling agitation caused in liquids by their active vaporization at the temperature beyond which the liquid can not exist under the ordinary pressure, i. e., its boiling point. But it is frequently necessary or desirable to heat liquids at or near the boiling point for other purposes than to vaporize them, as: to aid solution, to promote chemical reactions, to destroy certain objectionable constituents, etc.

For this purpose *boiling vessels* are employed, such as flasks, *deep* dishes, etc.
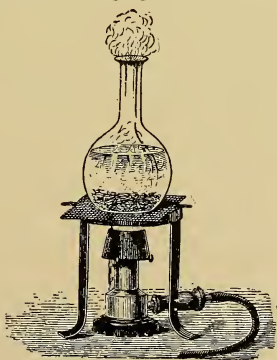
Fig. 131. Boiling flask.

1448. **Evaporating dishes**, on the contrary, are shallow, because the exposure of an extended surface of the liquid is one

Figs. 132 to 135. Porcelain evaporating dishes.

of the necessary conditions of rapid evaporation. Figs. 132 to 135 represent small porcelain evaporating dishes, such as are most useful to pharmacists.

To promote evaporation we may: 1, use shallow vessels; 2, apply heat; 3, stir the liquid so as to facilitate the escape of the vapor from the interior of the liquid; 4, constantly change the air above the evaporating liquid, replacing the saturated air by drier air, which is accomplished by creating currents in the act of stirring the liquid or otherwise, or by arranging so that there is a draft or continuous change of air in the whole room where the evaporation is going on; 5, so arrange that as large a portion of the outer surface of the evaporating dish is exposed to the heat as practicable; and 6, by lessening the pressure superimposed upon the evaporating liquid.

1449. Evaporating dishes are made of porcelain, glass, copper, silver, tin, enameled iron, "agate ware" or "granite ware," etc.

1450. *Evaporation* is carried 1, to dryness; 2, to a given volume; 3, to a given weight; 4, to a given specific weight; 5, to a certain consistence; 6, to crystallization; 7, to granulation; 8, to the complete expulsion of some objectionable volatile constituent; 9, until there is no further loss of weight; etc.

1451. In conducting an evaporation it is necessary to know what temperature the substance will bear which is exposed to heat. Very many medicinal substances are so sensitive to heat that extreme care is necessary to avoid injuring them. The

water-bath is often used. A higher temperature than that afforded by the water-bath must not be used in the evaporation of solutions of organic substances.

1452. The **vacuum pan** is an apparatus in which a covered evaporating vessel is combined with an air pump and a condenser in such a manner that the atmospheric pressure is removed or lessened, whereby the evaporation is made to proceed rapidly at a lower temperature, while at the same time the contents of the evaporating pan is not exposed to contact with the air.

1453. **Distillation** is the vaporization of liquids in an apparatus so constructed that the vapor formed in one vessel is conducted into another vessel in which it is condensed back to the liquid state so that it can be recovered. The product is always liquid and is called the *distillate*.

1454. There are many different kinds of distilling apparatus. The most common are: stills, flasks and retorts.

1455. **Stills** are made of copper, tin, lead, iron, earthen ware, and other materials. The best stills are the simplest in form, which can be easily taken apart, cleaned, and put together again. The *body* of the still should have a sufficiently large opening at the top to render it easy to get at every portion of the interior in cleaning it. The *head* should also be of equally simple construction and should fit the top of the body perfectly. The general shape of a still, when the head is joined to the body, is like that of the retort shown in Fig. 136. If a horizontal line be drawn across the retort just below the tubulure in which the thermometer is inserted, the upper part, which is bent toward the left and then on a downward incline until it is inserted in the condenser, would represent the head of the still, while the body of the retort resting on the wire cloth over the flame of the gas burner represents the body of the still.

1456. Fig. 136 also shows a lamp stand supporting both the gas burner and the retort, a Liebig's condenser on the stand, and

a water vessel supplying cold water to the condenser, while a beaker placed on the table receives the warm water running out
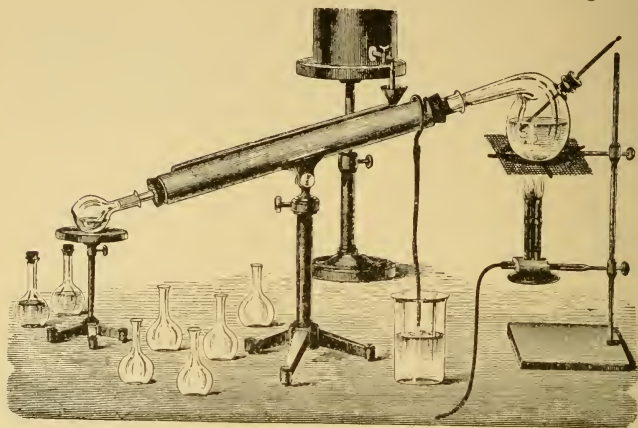
Fig. 136. Distillation.

of the condenser, and the whole apparatus is represented as in use in the separation of alcohol and water from each other by distillation ("fractional distillation"). Two flasks have already been filled with "distillate," and a third is now being used as a "receiver," while several empty flasks are on the table ready for use.

1457. **Retorts** are generally made of glass; sometimes of earthen ware. It is practically a flask with a long neck bent at an angle of about eighty degrees to the body. It should have one or two *tubulures* or necks with ground glass stoppers.

1458. **Flasks** are shown in Figs. 97, 131, 136, 138 and 139. Flat bottomed flasks are most convenient, but pear-shaped flasks are also useful. The neck of a distilling flask should be of large diameter, but not long. A wide neck is necessary to permit the insertion of perforated rubber stoppers or corks through which glass tubes, the thermometer, and other acces-

sories can be introduced. A glass tube extending only a short distance below the stopper and bent at a right angle about an inch above, serves the same purpose as the neck of a still or retort. A safety tube, or "thistle tube," is used for charging the flask or to add liquids to its contents from time to time; the upper thistle-shaped end serves as a funnel, and the lower end of the tube reaches nearly to the bottom of the flask.

1459. Condensers are tubes or other conduits in which vapors are *condensed* by abstracting from them their latent heat (401). The condensing space is usually surrounded by cold water which takes up that latent heat and becomes warmed by it; as the temperature of the water rises it becomes necessary to renew the supply of cold water continuously.

There are several different styles of condensers, of which we will mention only a few: the worm, Liebig's condenser, Mitscherlisch's condenser, the dome condenser, and the spiral glass tube condenser.

1460. The **worm** consists of a spiral block tin pipe placed in a tub, barrel or tank, through which cold water flows. The block tin pipe is connected at the upper end with the neck of the still, while the lower end passes out through the side of the tub, barrel or tank, near its bottom. The receiver is placed under this exit tube through which the distillate runs out.

1461. Liebig's Condenser consists of two tubes of different diameters, the smaller within the larger, fitted together by means of perforated stoppers or corks, or in some other convenient way. The inner tube protrudes at both ends, and the vapor is passed

Fig. 137. Liebig's condenser.

through it, while the outer tube carries the cold water.

1462. Mitscherlisch's condenser consists of a double cylinder, or of two tubes fitted together tightly at the ends and placed in a vessel of cold water. In this apparatus the condensing space is not within the inner tube or cylinder (as in Liebig's), but between the two cylinders or tubes, so that the vapor forms a thin sheet in the form of a cylinder. The inner tube is open at both ends. Hence the thin sheet of vapor is placed between the cold water outside and inside the double cylinder. Tubes are, of course, provided through which the vapor passes into the condensing space at the top, and the condensed liquid out of it at the lower end.

1463. The dome-shaped condenser is a funnel-shaped still head with a gutter running along its lower edge inside. When this head is fitted upon the still, the gutter being a trifle lower at one side, the vapor is condensed against the cold inner sides of the dome, and the resulting liquid runs down along those sides into the gutter and out through an exit tube at the lowest point. The dome is surmounted by a small tank of which the dome is the bottom, and cold water is supplied to it to effect the condensation.

1464. The upright small glass condensers, consisting of a spiral tube fitted into a larger tube shaped like a cylindrical percolator, are very convenient and effective.

1465. In all tube condensers the cold water is admitted at the bottom, and as it is warmed by the latent heat it absorbs from the vapor it rises to the top, where it is allowed to run off through a tube.

1466. Receivers used in connection with retorts and flasks are usually made of glass. They are globe-shaped flasks with wide necks admitting of the insertion of perforated corks or stoppers when required. Sometimes these receivers are fitted to the retorts without the intervention of condensers, the receiver being in that case a condenser at the same time; it may be placed in cold water or broken ice, or a stream of cold water may be kept flowing upon it.

1467. For large operations metallic stills are the best; for smaller operations either retorts or flasks. But retorts are so awkward in form, and the complete distilling apparatus of which a retort constitutes a part is so rigid, that the inconvenience and liability to breakage greatly lessen their utility. Flasks, which can be fitted to the condenser by means of rubber joints, are generally preferred, and retorts are used only for special purposes.

1468. Fractional distillation is the separation of liquids of different boiling points by distillation. When two or more liquids having different boiling points are mixed, and such a mixture is subjected to distillation, the most volatile liquid distills over before the others. Hence a separation of the several liquids by distillation is possible, the temperature being regulated accordingly. One of the constituents may be distilled over at one temperature, and another at a higher temperature. In some such operations the boiling point may remain constant for some time, and then rise to a higher degree and again become stationary for a time. But complete separation by such means is rarely possible, and even approximate separation requires repeated distillations, because portions of the less volatile liquids are vaporized and carried along with the vapor of the more volatile.

The distillation of mixtures of liquids for the purposes of separating them, collecting separately the portions distilling at different temperatures, is called fractional distillation.

A common instance of fractional distillation is the separation of alcohol from water. (Fig. 136).

1469. In many processes of distillation the vapor formed is the product of a chemical reaction taking place in the still, retort or flask. This may be called *chemical distillation*. The distillation of water, or of alcohol, for purposes of purification, is a simple distillation, because the distillate is not a new substance formed by a chemical reaction during the process of distillation. But if you mix alcohol and sulphuric acid and distill that mixture your distillate will contain ether—formed by the action of the acid on the alcohol.

1470. Closely resembling the processes of distillation is the generation of gases in flasks or other generators, with or with-
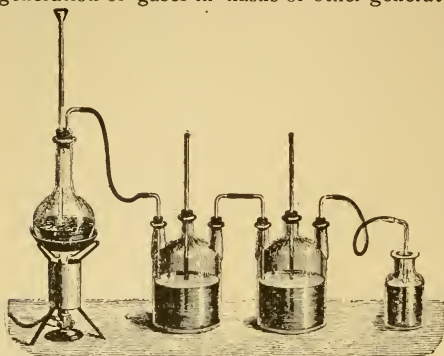
Fig. 138. Apparatus for the generation and solution of gases.

out the aid of heat, the gases thus formed (by chemical reactions) being passed through tubes into water or other liquids in which they are dissolved, being thus condensed to the liquid state by solution.

Condensers are generally unnecessary in such cases, the solvent contained in the receiver being sufficient to absorb the latent heat of the gas, or the receiver being surrounded by (or placed in) cold water or broken ice.

Sometimes the gas must be passed through water or other liquids *to wash it* before it is sufficiently pure to form a satisfactory product in the receiver. The receiver may be a flask, or a bottle, or any other convenient vessel, and in many cases it is necessary to disconnect it or remove it from time to time to shake the contents to facilitate the solution which is often carried almost or quite to the degree of complete saturation.

The *wash bottles* are usually the so-called "Woulf's bottles," or bottles with two or three necks, so that they can be connected by tubing with generator and receiver, and, if necessary, admit of the insertion of safety tubes to relieve pressure in case of the stoppage of tubes, etc.

Fig. 138 shows the generator (a flask) placed over a gas burner; a thistle tube is fitted to the neck of the flask, and the exit tube of glass connects by rubber tubing with two Woulf's

bottles (the "wash bottles") and with an end bottle. Either the second Woulf's bottle or the end bottle may be the receiver; if the second Woulf's bottle is the receiver then the end bottle generally contains some solution which *fixes* the excess of gas absorbing it by chemical action so as to prevent its escape into the room.

Fig. 139 and 140. Cutting glass tubing.

To cut glass tubing at any desired point, make a transverse indentation on one side by a few strokes with the edge of a three-cornered file, and then break the tube at that point, holding the tube as shown in Fig. 140, the thumb nails being under the tube and opposite the file mark, which should be held upward.

1471. Flasks, Woulf's bottles, receivers, and all other similar pieces of apparatus required for chemical processes in the
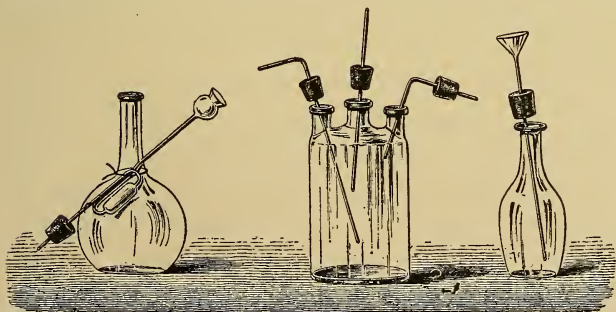
Fig. 141 to 143 Flasks and bottles with their fittings.

preparation of pharmaceutical products, should be carefully cleaned and put away when not in use, the rubber stoppers and

tubing belonging to them being tied to their necks, and the mouths of the necks capped with paper to keep out dust, etc.

When put together for use the glass tubes should be joined together with pieces of soft black rubber tubing.

1472. Among the official products made by processes involving distillation are: distilled water, alcohol, ether, chloroform, spirit of nitrous ether, etc., in the preparation of abstracts, oleoresins, and certain fluid extracts, extracts, etc., the greater part of the menstruum is recovered by distillation.

The methods of preparation of acids, chlorine water, the solutions of ammonia, etc., include "the generation and solution of gases."

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CHAPTER LXXXI.

CRYSTALLIZATION AND PRECIPITATION.

1473. Crystals, crystalline bodies, the formation of crystals, water of crystallization, and crystallography, were treated of in Chapters IV to VII, inclusive, Part I. These chapters should be reviewed here, and especially paragraphs 84, 100 to 105, 112, and 115 to 121.

1474. Pharmaceutically, the *process* of crystallization contemplates the production of chemicals in the form of crystals. It serves three useful ends: 1, the *separation* of crystallizable substances from amorphous (96) substances, or of two or more heteromorphous substances (95) when occurring together or when mixed; 2, *purification* (115 and 116); and 3, *improvement of the appearance* of the product.

1475. The several methods of producing crystals, or of inducing matter to assume the crystalline form, were briefly mentioned in paragraph 119 But we will now add a few practical considerations of special interest to the pharmaceutical chemist.

1476. By far the most common method of producing crystals is to induce their formation and growth in solutions. A crystallizable substance in a state of solution will separate from the solution in the form of crystals whenever the amount of solvent present is insufficient to retain the substance in solution. The ratio of solubility of a given solid in a given solvent is constant at any given temperature. A saturated solution of a crystallizable substance, therefore, deposits crystals whenever the amount of solvent is diminished by evaporation, or when the temperature of the solution is lowered (if the substance dissolved is soluble in greater proportion at a higher temperature).

There are accordingly two methods at once suggested by these considerations, by which we may cause the formation of crystals in solutions—*evaporation,* and the *reduction of the temperature* of the solution.

1477. The best **crystallizers**, or vessels in which to perform crystallization, are angular vessels with a rough interior surface. Perfectly smooth, spherical vessels, as dishes made of glass or glazed porcelain are not so good. For small quantities, however, glass and porcelain dishes are generally employed.

1478. Points of attachment.—If angular or rough particles, or sticks or strings, be introduced into solutions ready for crystallization, crystals will frequently begin to form at once upon their surfaces, and having been thus started the process goes on rapidly.

Ex.—Rock candy is crystallized on strings; ferrous sulphate on strips of sheet lead; copper sulphate and ferrocyanide of potassium on sticks of wood; etc.

1479. Nuclei.—In operating upon small or moderately large quantities, a convenient and effective method of promoting crystallization is to put into the salt solution a mass of crystals of the same salt. The crystals already formed will serve as *nuclei* for larger crystals, and to start the crystallization without delay.

1480. Size of Crystals.—If large and well-defined crystals are desired, their formation must be very gradual. Slow

cooling of the solution, or spontaneous evaporation of the sol-
vent, and perfect rest, are the means to be employed.
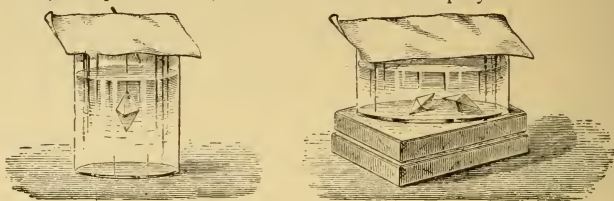
Figs. 144 and 145. The growing of perfect crystals of alum.

When quickly formed, on the other hand, the crystals are
small, and this will also be the result when the formation of the
crystals is interfered with by agitation. Rapid cooling of the
solution, or rapid vaporization of the solvent, and constant and
brisk agitation produce small crystals.

1481. Larger crystals are generally formed in turbid
than in clear solutions. Impure tartaric acid and citric acid
yield larger crystals than the pure acids. This shows that the
presence of foreign matters affect the process of crystallization,
which is also shown by other observed facts. Even the form of
crystals may be materially altered by the presence of other
bodies; thus the regular cubic form of sodium chloride may be
changed to the hemihedral form by the addition of small
amounts of urea, glycerin, or crude tartar, or by placing a cubic
crystal touched by fat or wax into the mother liquor.

1482. A powdered crystallizable salt, immersed in a sat-
urated solution of the same substance, gradually becomes coarse
and distinctly crystalline, the larger particles of powder serving
as nuclei for the crystals formed at the expense of the fine par-
ticles which disappear. The salt in solution deposits upon some
of the particles of powder, whilst a corresponding amount of the
finer particles of powder enters solution. Fluctuations in the
temperature hasten this change, for as the solution becomes
warmer it is no longer saturated, and therefore dissolves some
of the finest powder, and when it again becomes cooler the salt

which had dissolved at the higher temperature deposits upon the nuclei present, causing them to increase in size and distinctness of form.

This is exemplified sometimes in mixtures containing a larger quantity of some water-soluble salt than the water present is capable of holding in solution at common temperatures. When, for instance, the physician's prescription calls for two drachms of potassium chlorate, to be dispensed in a mixture containing less than two fluid ounces of aqueous solvent, more than one-half of the salt will remain undissolved, and even if added in the form of extremely fine powder, it will after a short time become coarsely granular.

1483. Nursing the crystals.—Crystals may be increased in size on the principle suggested in the preceding paragraph. The small crystals may be re-dissolved by gently warming the liquid in which they rest, and that is best effected by setting the vessel in a somewhat warmer place for a little while. The remaining crystals will grow when the temperature is again slightly lowered.

1484. Imperfect Development.—Crystals obtained from supersaturated solutions, or by fusion, are generally imperfect. Crystals resting upon the bottom or against the sides of the vessel, or against each other, can be but partially developed, and the result is usually a more or less confused mass of adhering or interlaced portions of crystals. Very rapid crystallization also produces imperfect crystals, as a rule.

1485. Retarded Crystallization.—It often happens that without any obvious cause the deposition of crystals is delayed, no signs of crystallization being seen for many days, or even weeks, although the solution may be sufficiently concentrated, and that afterwards it may suddenly begin. Sometimes one or but few crystals of large size may be found formed where a large crop is expected. At other times again the formation of crystals begins early and yet proceeds extremely slowly. In exceptional cases the completion of the deposition of crystals may require several months.

1486. The character and solubility of the salt; the form, size and inner surface of the crystallizer; the quantity operated upon; the degree of temperature and concentration of the solution; the constancy of the temperature of the air; and other conditions, may bear such relations to each other and to the crystallization as to cause unexpected rapidity or delay in the process.

1487. Water at perfect rest may be cooled to 8 or 10 degrees below the freezing point and still retain its liquid state; but a slight vibration imparted to the vessel will then cause sudden crystallization.

1488. The liquid remaining after the deposition of crystals has ceased, or the liquid in which the crystals are formed, is called the **mother-liquor.** This liquor can be used to dissolve additional quantities of the same substance by the aid of heat, and the solution then cooled to produce crystals. When large quantities of the same salt are to be crystallized or granulated, it is convenient and economical to employ the mother-liquor instead of a fresh portion of solvent for each succeeding operation.

1489. Granulation of salts.—Soluble salts may be *granulated* by rapid evaporation accompanied by agitation, or by rapidly cooling a hot saturated solution, stirring it constantly at the same time. The salt then separates in very small crystals. The crystals are small because they are rapidly formed, and because the agitation does not permit their growth. A salt in very small crystals is said to be granular, or granulated.

There is also another kind of granulated salts or products, of which " granulated citrate of magnesium " is an example. They are made by running a moist or dampened salt mass or mixture (it is usually moistened with alcohol) through very coarse sieves, rejecting both the fine and the too coarse particles, so as to produce a uniform size of *granules* which are nearly globular, but which, of course, do not have any crystalline structure. All that does not pass through a No. 20 sieve and all that does not pass through a No. 30 sieve is worked over.

1490. The crystals formed in solutions must be freed from adhering mother-liquor by draining them, or pressing them gently between cloth or bibulous paper, or by exposing them to a current of air until dry.

1491. Crystals obtained by sublimation are small and free when the vapor is rapidly condensed at a temperature considerably below that at which the vapor was formed; but a *cake* is usually formed when the vapor is slowly condensed at a temperature but little below the heat required for the sublimation.

1492. Precipitation as a pharmaceutical process has been discussed at considerable length in Chapter LX, because of the intimate relation it bears to certain chemical reactions. Paragraph 999 of a previous chapter states the law governing the formation of precipitates.

1493. Precipitation is the formation of insoluble solids in liquids. Precipitation takes place in a liquid previously free from undissolved matters, and consists in the formation of solid particles insoluble in that liquid.

Precipitation is the result of a change in the relation of the solvent to the matter it holds in solution. This altered relation may be brought about by a change in either the solvent, or the dissolved matter, or both.

1494. Distinction should be made between intentional precipitation as performed in chemical or pharmaceutical processes, and the unintentional precipitations which are so often observed in pharmaceutical preparations, and which usually take place so slowly as to closely resemble the formation of sediment in turbid liquids.

1495. Sediment.—Insoluble matter which deposits from a liquid, collecting at the bottom of the vessel, is not always a precipitate. Turbid liquids, holding insoluble matters in suspension, when allowed to remain at perfect rest a sufficient length of time, usually become clear by a slow separation of the solid matter which "settles" down at the bottom. This deposit is not a precipitate, but a sediment. When, however, the liquid is at first free from undissolved solid substances, but newly formed insoluble matters afterward separate from it in the solid state, this change is precipitation.

1496. Simple Precipitation is a precipitation unaccompanied by any chemical reaction. It is most frequently the result of an alteration of the solvent, as when resin is precipitated from its alcoholic solution by diluting the solvent with water, or when a gum is precipitated from its aqueous solution by the addition of alcohol, or when ferrous sulphate is thrown out of solution by pouring its aqueous solution into alcohol.

1497. Precipitation by reduction of temperature.—When saturated solutions are exposed to a reduction in temperature, a separation of solid matter may of course be expected, the result being either precipitation or crystallization, according to whether the solid is crystalline or amorphous.

1498. Chemical Precipitation is always the result of a chemical reaction whereby either the dissolved matter or the solvent, or both, are changed into new compounds, the solids produced by this change being insoluble in the liquid. Chemical precipitation is generally the result of "double decomposition."

1499. Precipitation resulting from slow chemical changes.—Precipitates are frequently formed in fluid extracts, tinctures, and solutions by chemical changes gradually produced under the influence of light, heat, contact with air, and the action of the dissolved substances upon each other or upon the solvent.

1500. Precipitating jars are vessels of glass or stone ware somewhat narrower at the top than below, so that the precipitates produced in them may fall to the bottom without coming in contact with the sides. But these vessels are seldom used. Precipitations are performed in various kinds of vessels, from a little test tube to a large tank. Beakers, wide-mouthed bottles, stone pots and barrels are the most common.

1501. The physical properties of precipitates depend much upon the temperature and degree of concentration of the solutions employed in producing them. Strong and hot solutions make denser precipitates; dilute and cold solutions make bulkier, more finely divided, and lighter precipitates (1031).

CHAPTER LXXXII.

METHODS OF EXTRACTION OF THE SOLUBLE MATTERS FROM PLANT
DRUGS.

1502. Extraction.—The various substances contained in
plant drugs may be extracted by means of proper solvents or
menstrua.

The objects are to separate the active constituents from the
inert, and to present the drug in a more convenient form for
medicinal use.

1503. Extract.—The product extracted from an organic
substance by any simple solvent is called an extract. It is usu-
ally a mixture of many constituents.

The term is sometimes applied to the whole solution formed
in the process of extraction, including all or nearly all of the
solvent employed.

Usually the term extract applies only to the residue obtained
when the solvent has been more or less perfectly removed by
distillation or evaporation.

1504. Extracts prepared in the course of organic analysis are classified
according to the solvents employed. Thus a water extract is one prepaied
with water, and hence containing chiefly water-soluble substances; an ether
extract is one made with ether and containing ether-soluble constituents ; the
terms benzin extract, alcohol extract, chloroform extract, etc., are respect-
ively used in a similar manner.

1505. The Extracts of Pharmacy are semi-fluid, soft
solid, or dry preparations obtained by extracting the soluble
constituents from drugs by means of simple solvents and evap-
orating the solutions until the products have the required con-
sistence.

1506. Extractive.—The bulk of the medicinal extracts is
usually made up of inert constituents common to all such prep-
arations, especially to those made with water or with water and
alcohol. These constituents, collectively, have received the
name *extractive*. Often they do not exist in the drug in the same
condition in which they are found in the extracts, having been
materially altered in the process of extraction, mainly by the
influence of heat and the exposure to air.

1507. Modifications of the extractive matter.—Whilst there is a general resemblance between the extractive of one extract and that of another, the character of the extractive varies with the drug, the menstruum, and the method of prepa. ration.

1508. General properties of Extractive. — Extractive matter is soluble in water and in alcohol; in solution it is darkened by exposure to air when heated at or near the boiling point, and then undergoes partial decomposition, one of the products of this decomposition being a black or nearly black deposit which has received the name of *apotheme*. It is stated that oxygen is absorbed and carbon dioxide given off during this change.

1509. The apotheme is sparingly soluble in water, but more readily soluble in alcohol, and freely soluble in alkalies. The alkaline solution is reddish brown, and the apotheme is precipitated from it when the alkali is neutralized by an acid.

In other respects the apotheme resembles *humus*, which is the principal constituent of the black soil formed by the slow decay of wood and leaves on exposure to air and moisture.

1510. The various **methods of extraction** are: maceration, digestion, infusion, decoction and percolation.

1511. Maceration is the more or less prolonged action of a menstruum upon a drug without the application of heat. The drug is usually coarsely comminuted, and the temperature of the solvent is the common room temperature—usually about 20° C. (68° F.), but in the summer season higher.

The liquid extract obtained by maceration is called a *macerate*.

In *simple maceration* the whole quantity of menstruum is at once mixed with the whole amount of the drug.

In other cases the menstruum is divided into two or more portions, and the whole quantity of drug is macerated first with one portion, and, after separating the first *macerate*, is then macerated again with another portion, etc. This is more effective than to add all of the menstruum at once. The most common rule for what might conveniently be called *re-maceration* is to divide

the menstruum into two portions, one consisting of two-thirds of the whole quantity and the second portion consisting of the remaining third, and to macerate the whole quantity of drug with the first portion of menstruum a given period, reserving this macerate, and then macerating the residue with the second portion of the menstruum for a period half as long as the first. Thus, if two pounds of drug is to be treated with fifteen pounds of diluted alcohol, it might be macerated first with ten pounds of the menstruum for six days, and afterwards with the remaining five pounds of the menstruum for three days, etc.

A still more effective method of maceration consists in dividing both the drug and the menstruum, and to treat each portion of the drug in turn with each portion of the menstruum successively.

1512. **Digestion** is a method of extraction similar to maceration in all respects except as to the temperature, which, in digestion, may be at any point between the ordinary room temperature and the boiling point of water. Usually the temperature in digestion is not above 60° C. (104.° F.), but full water-bath heat is sometimes employed

In digestion as well as in maceration the drug may either be treated with the whole quantity of menstruum at once, or with a portion at a time, or both drug and menstruum may be divided. (1511.)

1513. The process of **infusion** is nearly the same as digestion. It is the immersion of comminuted drugs in boiling *water*
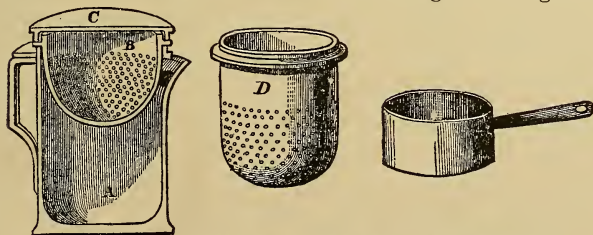
Figs, 146 and 147, Squire's infusion pot, illustrating circulatory displacement.
Fig. 148, Decoction vessel.

without maintaining the high temperature. Boiling water is poured upon the drug or species (1536), and the infusion vessel is set aside in any convenient place, the temperature of the contents being allowed to fall until it is the same as that of the atmosphere of the room unless the preparation is finished before that point is reached.

The term "infusion" is also applied to the product obtained by the process here described, and even to certain macerates and percolates made with water and constituting finished preparations.

1514. **Coction**, or *decoction*, is the process of extracting soluble matters from plant drugs by exposing the latter to the action of water at its boiling point. This differs from infusion in that the boiling point is maintained from beginning to end in coction or decoction, while infusion only *begins* near the boiling point but ends far below it.

Sometimes the amount of water added to the drug is twice the volume of the intended product, and the boiling continued until the volume is reduced by evaporation to the requisite measure. The general practice, however, is to add only an amount of water equal to the desired quantity of product, and to replace from time to time the water lost by evaporation, so as to maintain about the same volume to the end.

1515. Maceration, digestion, infusion and decoction are all employed, not only in the preparation of infusions and decoctions, but far more frequently in the preparation of extracts and other products.

1516. The forces and phenomena concerned in the extraction of the soluble contents of drugs by these several methods are various. Thus the menstruum is absorbed into the tissues of the particles of drug by *capillarity* (152 to 167); it passes into closed cavities in the plant tissues by *osmosis* (169 to 178); liquefies the soluble contents by solution (183); separates crystalloids from colloids by *dialysis* (179 to 182); the portions of solution thus formed mix with each other and with the menstruum on

the outside of the particles of drug by *diffusion* (168); and the final liquid extract is then separated from the drug by expression or by displacement (1517).

1517. Displacement.—Dissolved or readily soluble matters may be *displaced* or washed out from the insoluble matters with which they are associated, as from the tissues of drugs, by the descending current of a solvent. This is called *displacement.*

Thus when a powdered drug has been macerated with its proper menstruum, in a percolator, until the soluble constituents have been reached and liquefied by the solvent, the solution thus formed may be "displaced" from the mass by adding more menstruum from above, and allowing it to descend slowly.

1518. Percolation is the extraction of the soluble constituents from powdered organic drugs by *solution* and downward *displacement* with successive portions of menstruum, the process being conducted in suitable vessels (called *percolators*), and in such a manner that the first portion of liquid in its descent through the mass forms a highly concentrated solution, the density of the subsequent percolate decreasing regularly, until the drug is exhausted.

The liquid extract which passes out of a percolator in operation is called a **percolate**.

1519. The Pharmacopœia describes a cylindrical percolator such as is suitable for the official processes. Very similar to the pharmacopœial percolator, but taller in proportion to its diameter, and more finished in its details, is the percolator designed by the author (Fig. 149). The top of this percolator is ground smooth, so that by applying a little glycerin to it, and putting a plate of glass over it, the percolator is tightly closed. The stem is a
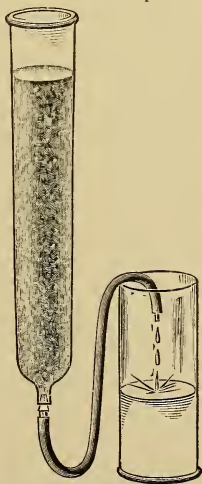
Fig. 149. Oldberg's percolator.

perfect bottle neck, so that the perforated rubber stopper is easily inserted in it.

The rubber tube may be raised or lowered to lessen or increase the rate of flow of the percolate.

1520. The special advantage of percolation over the simpler methods of extraction lies in the fact that the menstruum employed passes through many successive portions of drug so that each particle of the solvent is used many times over until it becomes so charged with dissolved matters that its solvent powers are utilized to the greatest practicable extent. In percolation, therefore, it is possible to completely exhaust the drug with a smaller quantity of menstruum than would be required to accomplish that result by maceration, digestion, or other methods.

1521. Drugs not containing over fifty per cent. of extractive matter may be successfully percolated unless the soluble matter consists largely of resin or of gum. But extract-like drugs (opium, aloes, kino, catechu), gum-resins (like asafetida and myrrh), resins (like tolu, benzoin, guaiac) are not subjected to percolation, their tinctures and other extracts being made by maceration.

1522. Tall percolators are to be preferred, because they are adapted to all kinds of drugs capable of being exhausted by percolation. The taller the column of drug through which the menstruum must pass, the greater will be the quantity of soluble matter which that menstruum must take up in solution before it passes out of the percolator. But it is not possible to increase the height of the column of drug without limit, for not only would the apparatus be awkward to manage if too tall, but too tall a column of a drug containing a large amount of extractive would render the density of the solution so great before it reaches the bottom of the percolator as to arrest its farther descent. A tall percolator should be filled if the drug contains a comparatively moderate amount of soluble matter; but it should *not* be filled with a drug containing so large a quantity of extractive as to afford a solution too dense to pass through the column of drug without difficulty.

1523. Percolation is rendered effective by combining it with maceration or digestion, which should be sufficiently long continued to permit the menstruum to reach and liquefy the constituents of the drug, and to completely prepare the packed mass of drug for the displacement. Much of the soluble matter is in many cases at once dissolved and displaced by the descending menstrnum, even before any liquid is permitted to pass out of the percolator, but the drug can not be exhausted by percolation without maceration except with a considerably greater amount of menstruum.

1524. The several consecutive steps of the process of extraction by percolation are as follows: 1, the air-dry drug in a state of powder of suitable degree of fineness is moistened with a sufficient quantity of menstruum to render it uniformly *damp* when well mixed with it; 2, the dampened powder is then allowed to lie long enough to thoroughly absorb the menstruum thus used, so that if the drug has a tendency to swell when moistened, this swelling of the particles may take place before tne drug is packed in the percolator (except in a few special cases, where experience has shown that it is better to pack and percolate without delay); 3, the moist drug is then packed *uniformly* in the percolator, neither too firmly nor too loosely; 4, a sufficient quantity of menstruum is now poured upon the packed mass to saturate it from top to bottom, leaving a stratum of liquid standing over the top of the packed drug; 5, then the percolator is allowed to rest, with the lower end of the rubber tube raised and fastened to the top of the percolator while maceration takes place; 6, when the necessary period of maceration has been completed, the tube is let down and inserted into a suitable receiver (an ordinary bottle is a very good receiver for this purpose), and the liquid in the percolator is permitted to run out, while more menstruum is added from time to time at the top, and the percolation is allowed to continue until the drug is exhausted.

The percolate is sometimes collected all in one lot; sometimes the first percolate is set aside to be mixed with the subsequent

percolate only after the latter has been concentrated by evaporation.

1525. The scope of this book does not admit of greater detail in the description of this important process, but I regard it necessary to say to the student that the details of the process are governed by the nature of each drug operated upon, and that much practice is necessary to master them all, so that there is much to learn even after the general principles have become known to you.

1526. Coarse powder is generally used when water or a weak alcoholic menstruum is used, while fine powder is used when the menstruum is strongly alcoholic. But this question is also affected by the character and constituents of the drug regardless of the kind of menstruum employed.

1527. Simple percolation is the process described in paragraph 1524. The whole amount of drug is packed in the percolator and the menstruum used is new menstruum—not a weak percolate from a previous percolation of the same drug.

1528. In **Re-percolation** the drug and the menstruum are both divided into several portions, and each new portion of drug is completely exhausted by percolation with successive portions of liquid, the first portion being a weak percolate from a previous operation, the second a still weaker portion of the percolate from the percolation of the last previous lot of the same drug, and the last portion of menstruum used is new menstruum.

1529. In making fluid extracts by re-percolation the percolate is always collected in several portions. The first portion is finished fluid extract, the next portion is the first *weak percolate*, then comes the second, and the third, and fourth weak percolates—each collected separately, labeled properly, and put away to be used as menstrua in the next percolation of *an equal amount* of the same drug.

That the result will be uniform and the strength of the fluid extract exactly in accordance with the Pharmacopœial standard, may be easily understood from the following supposed case: If

the quantity of drug operated upon each time be 10 pounds, and each 10-pound lot be completely exhausted, and if it takes three portions of weak percolate of 10 pounds each, and one portion of new menstruum, also 10 pounds, to accomplish the complete exhaustion of each such lot of drug, then it follows that when ten such lots of the drug have been used we should have received 10 pounds of fluid extract from each lot, and would have used 10 pounds of new menstruum instead, at the end of each percolation, and in every case we would have 30 pounds of weak percolates on hand for next time. And the next ten lots would still leave us in precisely the same position. Therefore, if the work is well done, the result must be uniform and proper.

1530. When concentrated liquid extracts, like our official fluid extracts, are to be prepared, re-percolation is an especially valuable process because it renders it unnecessary to resort to evaporation.

1531. Complete saturation of the menstruum with dissolved matter is rarely, if ever, accomplished in percolation, although it often happens that the density of the solution first formed is so great as to retard, if not wholly arrest, the flow of the percolate.

1532. Complete exhaustion of the drug by percolation is frequently attainable without employing an unreasonably large amount of menstruum. It may be closely approximated in all cases, provided the work is skillfully done.

1533. Marc.—The residue left after extracting the soluble matters from drugs is called the *marc*.

This marc retains a considerable quantity of the menstruum, held by capillarity. When this menstruum is valuable it is usually recovered by distillation.

CHAPTER LXXXIII.

PHARMACEUTICAL PREPARATIONS—CLASSIFICATION.

1534. Definite chemical compounds used as medicines, such as salts, haloids, acids, oxides, etc., whether inorganic or organic, have a comparatively simple pharmacy, because medicines consisting of only one substance are ready for use as soon as made into powder or solution, or even without further preparation. They may be used alone, or mixed with other substances, in any desired form.

Organic crude drugs, however, like roots, barks, leaves, etc., which contain or consist of many different substances, some of which are medicinally valuable, others entirely inert, and still others objectionable, have a more complex pharmacy, because one of its most important objects is the separation of these several classes of constituents from each other with the view to the presentation of the active principles in the most convenient, effective and uniform condition. This involves the application of intelligent methods of extraction and concentration, and the production of classes of preparations wholly different from the chemicals.

1535. The pharmaceutical preparations might conveniently be classified into six groups, as follows:

Preparations for Internal use.

Class 1. DRY AND SEMI-SOLID PREPARATIONS FOR INTERNAL USE MADE BY PROCESSES NOT INVOLVING EXTRACTION.—They include: Species, powders, triturations, confections and electuaries, masses, troches, boli, pills and granules.

Class 2. LIQUID PREPARATIONS FOR INTERNAL USE NOT MADE BY EXTRACTION.—Solutions, waters, mucilages, syrups, honeys, glycerites, mixtures, emulsions and spirits.

Class 3. LIQUID EXTRACTS.—Infusions, decoctions, vinegars, tinctures, wines, and fluid extracts.

Class 4. DRY AND SEMI-SOLID PREPARATIONS MADE BY PROCESSES WHICH INCLUDE EXTRACTION.— Extracts, abstracts, oleo-resins and resins.

Preparations for External use.

Class 5. SOLID AND SEMI-SOLID PREPARATIONS FOR EXTER-
NAL USE.—Cataplasms, medicated papers and tissues, ointments,
cerates, plasters and suppositories.

Class 6. LIQUID PREPARATIONS FOR EXTERNAL USE.—Gargles,
lotions, injections, collodions, liniments.

CHAPTER LXXXIV.

PREPARATIONS OF CLASS I (1535).

1536. Species are cut or otherwise coarsely comminuted
drugs, single or mixed, intended for the preparation of teas,
decoctions, bitters, poultices, etc. Breast teas, laxative teas,
worm teas, etc., are common examples.

1537. Powders.—*Simple powders*, dispensed alone or mixed
with other substances, must be quite fine and uniform.

The Pharmacopœia does not prescribe the particular degree of
fineness for each drug commonly employed in the form of pow-
der. Such powders should in no case be less fine than No. 60,
and may with advantage be much finer; many drugs should be
used in No. 100 to 120.

Compound powders are usually composed of simple powders,
but even moist ingredients are frequently incorporated in them.
The official compound powders are 9.

They are prepared by trituration (1385).

Whenever a small quantity of one substance must be mixed
with a comparatively large quantity of another, the latter should
be added, a little at a time, trituration following each addition.

1538. Triturations are dilutions of potent remedies with
sugar of milk in the form of powder, and containing ten per
cent. of the active ingredient.

There is 1 trituration in the Pharmacopœia—that of elaterin.

Other triturations may be made of tartrate of antimony and potassium, morphine, strychnine, or any medicinal agent, the dose of which is less than one grain.

1539. **Confections** and **electuaries** are solid or semi-solid strongly saccharine preparations.   They are sometimes also called *conserves*.   They are drugs or mixtures of drugs usually in a moist condition preserved and sweetened with sugar, honey or syrup.

There are 2 such preparations in the Pharmacopœia—the confection of rose, which is quite useless, and confection of senna.

Electuaries are soft confections.

Any powder made into a soft mass with any syrup or honey is a confection if it contains organic drugs to be preserved by the sugar, but an electuary if it consists of inorganic substances, simply massed and sweetened with the saccharine liquid.

1540. **Masses** are mixtures of medicinal substances made of such consistence that they may be formed into pills.   The Pharmacopœia contains 3 masses — those of mercury and copaiba, and the " mass of carbonate of iron."

1541. **Troches** are dry, or only slightly plastic, flat lozenges or tablets, made of medicines mixed with sugar, syrup, or extract of glycyrrhiza, and weighing usually from 10 to 20 grains.

The ingredients are massed with mucilage of tragacanth or some other suitable excipient, the mass is rolled out into sheets, and the troches are cut out with "lozenge cutters," the simplest of which is a tin tube.

There are 16 different kinds of troches in the Pharmacopœia.

1542. **Boli, pills** and **granules** are little, solid masses of medicinal substances, sufficiently firm to retain the form given to them.   Boli may be cylindrical, oblong, or round; pills may be round or oval; but granules are always round.   Boli weigh

usually about 10 grains or more; pills from 1 to 5 grains, but most frequently from 2 to 3 grains; while granules weigh less than 1 grain. Practically, the difference between a bolus, a pill and a granule, is simply a matter of size.

The kinds of substances entering into these preparations are powders, extracts, abstracts, oleoresins, chemicals, volatile oils, and many other materials.

The ingredients are well mixed, and if they are not of such a nature as to form together a mass of suitable consistence, then one or more *excipients* must be added to mass them properly. Dry ingredients require moist excipients; moist or soft ingredients require dry excipients; a wet mixture requires an absorbent excipient; insoluble and non-adhesive materials require adhesive excipients, etc.

The mass must be firm, yet plastic enough to be easily formed into pills; it must be perfectly uniform and smooth, and cohesive, but not sticky on the surface.

To prevent pills from sticking to the fingers when they are being made, or to each other afterwards, they are dusted with some inert, insoluble, tasteless and inodorous powder. Such a powder, so used, is called a *conspergative*.

For colored masses the best conspergative is lycopodium, while rice flour is the best for white pills.

Among the best *moist excipients* are: water, diluted alcohol, glycerin, glucose, syrup, honey and mucilages of acacia and tragacanth.

Among the best *dry excipients* are: tragacanth, acacia; slippery elm, althæa and glycyrrhiza; flour and starch; and milk sugar.

Various *special excipients* are also employed.

There are 15 different kinds of pills in the Pharmacopœia.

CHAPTER LXXXV.

PREPARATIONS OF CLASS 2 (1535).

1543. Solutions (*liquores*) are a group of preparations con-
sisting chiefly of "*water-solutions of non-volatile substances.*"

There are 24 such preparations in the Pharmacopœia.

"Solution of gutta-percha" is made with chloroform.

Several of the official solutions are simply used as materials
from which to make other preparations.

It should not be forgotten that there are many "water solu-
tions of non-volatile substances" which are not called "liquores"
or solutions, as for instance the mucilages and syrups.

Many of the *liquores* are simple solutions of definite chem-
ical compounds, while others are of somewhat indefinite com-
position and strength. Some are prepared by simple solution ;
others by processes involving chemical reactions.

1544. Waters (*aquæ*) are defined as "*water solutions of vola-
tile substances.*"

But they are a very mixed group of preparations. Most of
them are *aromatic waters*—solutions of volatile oil in water. But
such totally different preparations as chlorine water, ammonia
water, etc., are also given the generic title "aqua."

The aromatic waters are generally made by reducing the
volatile oil to a very minute subdivision, and then bringing it
into intimate contact with water. This may be accomplished
in several ways. One method is to triturate the volatile oil with
magnesium carbonate and a little water to a smooth, soft paste,
and then shake that with the rest of the water and filter. Cal-
cium phosphate may with advantage be used instead of the
magnesium carbonate, and tepid water gives a better result than
cold water.

The present Pharmacopœia (1890) prescribes that the vola-
tile oil be distributed on calcium phosphate and that the water
be mixed with these and then filtered.

There are 19 kinds of "waters" in the Pharmacopœia.

1545. Mucilages are solutions of gums or vegetable mucilage. All are made without the aid of heat.

There are 4 official mucilages. those of acacia and tragacanth, and the less frequently used mucilaginous cold infusions of quince seed, slippery elm bark, and sassafras pith.

Mucilages spoil rapidly and must therefore be prepared as wanted for use.

1546. Syrups are concentrated solutions of sugar in water or in watery liquids, either with or without active medicinal constituents. Many syrups (as for instance the fruit syrups) are used simply as sweetening and flavoring additions to mixtures. Others are medicated with either inorganic chemical compounds in solution, or made with organic liquid extracts such as fluid extracts, infusions, etc.

The sugar acts as a preservative as well as a sweetening agent in the medicated syrups. The amount of sugar necessary to protect the product from fermentation is about 65 per cent. when organic matters only are present, except that the presence of volatile oils and other preservative substances warrant some reduction of that proportion. But syrups containing inorganic chemicals will keep with much less sugar.

Syrups should be kept in a cool place.

There are 32 different syrups in the Pharmacopœia.

Honeys (*mellita*) resemble the syrups in that they are strong saccharine liquids.

Honey of Rose is official.

Hydromel is a mixture of equal volumes of honey and water, and *oxymel* a mixture of equal volumes of honey and diluted acetic acid.

1547. Glycerites are glycerin solutions of medicinal substances, or mixtures of glycerin with other substances for pharmaceutical uses. The only official glycerites now (1895) are glycerite of starch, which is used as a base for certain ointments, and glycerite of yolk of egg, which is used as an emulsifying agent, and 4 solutions of medicinal agents in glycerin.

1548. Mixtures and Emulsions.

Mixtures are liquid preparations containing insoluble matters in a fine state of division suspended in watery menstrua, or compound liquid preparations containing organic substances dissolved in watery fluids. The group of preparations which the Pharmacopœia places together under the title Misturæ consists of widely different products which might advantageously be subdivided. Thus there is one seed emulsion, two simple gum-resin emulsions, one compound gum-resin emulsion, and one simple and two complex solutions, containing no undissolved matter, among the numbe

An *emulsion* is a uniform liquid preparation containing finely divided insoluble matter (solid or liquid) held in suspension in a watery menstruum. The insoluble substances held in suspension are usually either fixed oils, volatile oils, or resins. Thus a seed emulsion holds fixed oil, an emulsion of a gum-resin holds volatile oil and resin, and cod liver oil, castor oil, olive oil, oil of almond, copaiba, oil of turpentine, guaiac, etc., may all be *emulsified*.

To hold these substances in suspension for an indefinite period they must be in an extremely fine state of division, and an efficient *emulsifying agent* must be present in sufficient quantity.

The best emulsifying agents are gums and albuminoids. Acacia is by far the best; but tragacanth, yolk of egg, and Irish moss jelly are also used. A *seed emulsion* is formed when a seed is beaten up to a smooth, soft pulp with water, and more water added afterwards. Almond mixture (almond
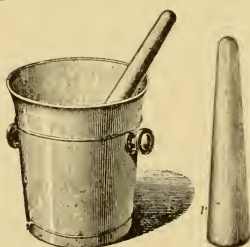
Fig. 150. An almond emulsion mortar. emulsion, or almond milk) is a perfectly white, milk-like emulsion in which the fixed oil of the almond is emulsified an ' suspended by the albuminoid *emulsin,* which is the white fle   of the almond. But the addition of acacia and sugar m⌐   preparation richer. The almonds are "blanched." An almonu emulsion mortar is shown in Fig. 150.

Gum-resin emulsions are formed whenever a gum-resin is tritu-
rated with water. In such an emulsion the resin and volatile
oil are emulsified and suspended by the gum—all of these con-
stituents being contained together in the gum-resin.

An *emulsion of fixed oil* is best made by first mixing the oil
with half its weight of powdered acacia in a mortar, being very
careful to leave no unmixed portions of either gum or oil; then
add *at once* a quantity of water equal to ⅝ of the combined
weight of the oil and gum used, and *immediately* proceed to mix
all by an extremely rapid rotary motion of the pestle without
pressure until the mixture thickens, becomes whitish, uniformly
smooth, and gives a crackling sound under the pestle. The
emulsification of the oil is then completed, and more water, if
required, may afterwards be *gradually* added during constant
stirring. The definite proportion of water first used is called
the *water of emulsification*. A greater or a less proportion of water
of emulsification than specified in this paragraph works less satis-
factorily, and any considerable deviation defeats the object in view.

Emulsions of volatile oils (as of oil of turpentine) and of
oleo resins (as of copaiba) are prepared in the same manner as
emulsions of fixed oils, except that twice as large a proportion of
powdered acacia is required, viz.: the same weight of acacia as
of volatile oil or oleo-resin.

The ordinary wedgewood mortars are well adapted for the
preparation of emulsions of fixed and volatile oils, oleo-resins,
and gum-resins.

There are 4 different so-called "mixtures" in the Pharma-
copœia, and 4 emulsions.

1549. Spirits are *"alcoholic solutions of volatile substances."*

Most of the "spirits" of the Pharmacopœia are alcoholic
solutions of volatile oils. But there are quite a variety of other
liquids called spirits, as the spirit of ether, which is simply a
mixture of alcohol and ether; spirit of ammonia, which is a
solution of ammonia in alcohol; aromatic spirit of ammonia,
which is a flavored solution of ammonium carbonate; spirit of
chloroform; Cologne water; spirit of nitrous ether, which is
to contain 5 per cent. ethyl nitrite; and brandy and whiskey.

CHAPTER LXXXVI.

PREPARATIONS OF CLASS 3 (1535).

1550. Infusions are weak liquid watery extracts of plant drugs, prepared by infusion, maceration or percolation.

They are rather crude unreliable preparations, because the menstruum and the methods of preparation are not such as to insure complete exhaustion of the drug.

There are 4 official infusions. Boiling water is used in the preparation of three of them—those of Brayera, Digitalis and Senna (compound).

Brayera is used in No. 20 powder, and the infusion is not strained ; in other words it is a crude mixture rather than an infusion, for water does not extract the active matter of Brayera, and that is the reason why the preparation is not to be strained.

Infusion of *Digitalis* is flavored with cinnamon and preserved with alcohol; the digitalis and cinnamon are used in No. 20 powder.
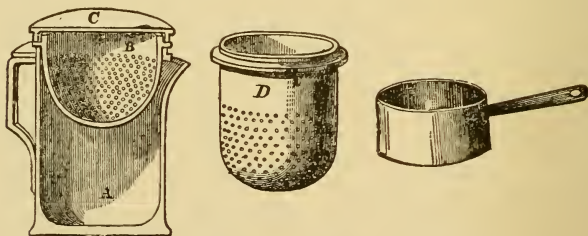
Figs. 151 to 153. Infusion and decoction vessels.

In the preparation of Compound Infusion of *Senna*, the Senna is used *whole* to avoid the extraction of much mucilage. The other ingredients in this preparation are magnesium sulphate manna, and fennel.

Infusion of *Cinchona* is made by percolation with cold water,

acidulated with about one per cent. aromatic sulphuric acid. The bark is in No. 40 powder.

Infusion of *Wild Cherry* is a cold water percolate of the bark in No. 40 powder.

But the *general formula* of the Pharmacopœia prescribes that in making any "ordinary infusion" the coarsely comminuted drug shall be put in a suitable vessel and ten times its weight of boiling water poured upon it, after which it is to "stand two hours," and is then strained. The Pharmacopœia adds a "caution" to the effect that "the strength of infusions of energetic and powerful substances should be specially prescribed by the physician."

1551. Decoctions are weak liquid water extracts of plant drugs, prepared by coction (1514).

Decoction of Cetraria and the Compound Decoction of Sarsaparilla are the only two now official (1895).

The general official formula says that an "ordinary decoction" is to be made by putting the coarsely comminuted drug in a suitable decoction vessel, adding ten times its weight of cold water, covering well, boiling for fifteen minutes, then straining.

The same "caution" is then added as in the case of infusions (1550).

1552. Vinegars (*aceta*) are liquid preparations prepared by extracting the active principles from plant drugs with diluted acetic acid.

Some drugs containing alkaloids or acrid neutral principles are represented by preparations of this kind.

They are prepared by percolation.

Two are at present official, both of 10 per cent strength with reference to the drug.

1553. Tinctures are defined as "*alcoholic solutions of non-volatile substances.*" Sometimes they are defined as "alcoholic solutions of medicinal substances." But fluid extracts would be included under the first definition, and both fluid extracts and most of the spirits under the second.

With very few exceptions the official tinctures are alcoholic liquid extracts weaker than the fluid extracts.

There are 71 tinctures now official (1895).

Tinctures of crude plant drugs are made by percolation; those of resins, gum resins, extract-like drugs, and a few others that can not be percolated are made by maceration or by simple solution.

Tinctures may be classified into *alcoholic*, which are made with a strongly alcoholic menstruum; *hydro-alcoholic* tinctures, which are made with diluted alcohol; *ammoniated* tinctures, made with aromatic spirit of ammonia, and *ethereal* tinctures, made with ether or containing a considerable portion of ether.

Tinctures are not of uniform percentage strength as a class; they range from 5 per cent. to 50 per cent., the greater number being 10 or 20 per cent.

Fifteen of the official tinctures are made from more than one ingredient aside from the menstruum; these are called *compound* tinctures. The others are *simple* tinctures.

Among the official tinctures are included three that contain inorganic constituents, namely: the tinctures of iodine, ferric acetate and ferric chloride.

The Pharmacopœia gives a general formula for the preparation of *tinctures of fresh plant parts*. This provides that the bruised or crushed plant drug shall be covered with twice its weight of alcohol and macerated 14 days, after which the liquid is expressed and filtered.

1554. **Wines** are solutions or liquid extracts, the menstruum of which is wine.

They are made by simple solution, or by maceration or percolation.

There are 10 official wines, including the two kinds of unmedicated wine.

1555. **Fluid Extracts** are liquid extracts of plant drugs so prepared that each Cubic centimeter represents the medicinal contents of one Gram of drug. (This is practically minim for grain.)

They are alcoholic, or hydro-alcoholic.

Fluid extracts are the most concentrated liquid extracts of plant drugs that have ever been officially recognized, and they contain so large an amount of soluble matter in many cases that they require to be prepared with very great care, especially because the amount of final product is far less than the quantity of menstruum necessary to exhaust the drug, which necessitates the concentration of a portion of the liquid extract by evaporation to bring the whole volume within the prescribed limit.

Fluid extracts are nearly all made by percolation. The first portion of percolate (to the amount of from $\frac{7}{10}$ to $\frac{9}{10}$ of the bulk of the final product) is set aside as soon as collected, and the remainder of the percolate is evaporated to a soft pasty extract, which is then dissolved in the reserved portion enough new menstruum being finally added to make the total volume of the product what it should be according to the pharmacopœial standard of strength—1 Cubic-centimeter for each Gram of drug.

There are 88 official fluid extracts.

CHAPTER LXXXVII.

PREPARATIONS OF CLASS 4 (1535).

1556. Extracts are dry or moist solids, sometimes quite soft, prepared by extracting soluble matters from plant drugs with suitable menstrua, and evaporating the liquid extracts thus obtained until they have the required consistence.

Whenever the solid extract yielded is capable of being rendered entirely dry without injury to its constituents, that is usually the course pursued. But when the extract can not be safely evaporated to dryness it is instead mixed with a small

quantity of glycerin to keep it permanently sufficiently moist and soft to be conveniently used.

Dry solid extracts are generally reduced to powder.

The yield of solid extract from plant drugs varies all the way from about 3 per cent. (in the case of physostigma) to about 40 to 50 per cent. (in rhubarb and opium).

Solid extracts are alcoholic, hydro-alcoholic, or aqueous according to the menstruum used in their preparation.

The menstruum used should be one which will extract all of the active or valuable constituents but at the same time as little as possible of other soluble contents of the drug in order that the product obtained may be reduced to a minimum of weight and a maximum of medicinal potency.

The methods of extraction employed in the preparation of extracts are percolation, maceration, and digestion.

The evaporation is produced by the heat imparted by the water-bath (1365).

There are 33 official extracts.

The aqueous extracts are those of: aloes, hæmatoxylon, opium, malt, taraxacum, gentian, glycyrrhiza, krameria, and quassia.

There is one *acetic* extract, prepared with water containing over 23 per cent. official acetic acid ; this is the extract of colchicum root (corm).

One official extract is compound—the compound extract of colocynth.

Solid extracts should, of course, not be made of drugs containing volatile active constituents, nor of drugs whose active principles are liable to be decomposed or damaged by exposure to heat.

1557. **Abstracts** are powdered solid extracts containing added sugar of milk in such quantity as to make the product represent the medicinal activity of twice its weight of the crude plant drug.

As they are dried and powdered, the menstruum used is nearly always undiluted alcohol, which renders the drying

process less risky than if a less volatile menstruum were employed

The drug is exhausted by percolation, the evaporation is conducted at as low a temperature as possible, the drying facilitated by the addition of a portion of the sugar of milk, the rest of the sugar of milk being added after the drying so as to make the weight of the first product one-half of that of the drug used, and the abstract is finally reduced to a very fine powder.

There were 11 abstracts in the former Pharmacopœia (1880).

Abstracts can be made of all drugs not yielding too great an amount of extractive, and not sensitive to the heat necessary to render the product dry enough to be reduced to fine powder.

1558. **Oleoresins** are extracts made with stronger ether as the menstruum, and consisting chiefly of volatile oil and resin.

They are made by percolation. The *dry* drug is packed in the percolator, and the menstruum then added, the whole apparatus (percolator and receiver) being tightly closed to prevent evaporation of the ether, the top of the percolator being connected by a bent glass tube with the top of the receiver to remove the pressure which would otherwise prevent the descent of the percolate. The ether is then removed by distillation and evaporation.

There are 6 official prepared oleoresins, which are fluid or semi-fluid.

Stronger ether is prescribed as a menstruum because if a less volatile menstruum is used the volatile oil would be partly lost in the evaporation.

1559. Precipitated **Resins** are made by exhausting resinous drugs by percolation or digestion with alcohol, distilling off most of the menstruum, and mixing the concentrated alcoholic tincture (or solution of resin) with a sufficient quantity of water to cause the resin to precipitate. The resin is then washed, dried and powdered.

The precipitated resins of the Pharmacopœia are those of jalap, podophyllum and scammony.

Resin of copaiba is the residue obtained when the volatile oil is distilled off from copaiba.

CHAPTER LXXXVIII.

PREPARATIONS FOR EXTERNAL USE.

1560. Cataplasms or poultices are frequently employed, but there is no preparation of this kind now official. The most common cataplasms are "mustard plaster" and flaxseed poultice.

1561. Medicated papers and **tissues** are much used. Paper, silk, and cotton fabrics are either impregnated with some medicament by immersion in its solution, or are painted over with it on one side.

Mustard paper is official under the title of *charta sinapis*. The *charta potassii nitratis* is unsized paper dipped in a solution of potassium nitrate and dried; it is used by being burnt in the sick-room.

Blistering tissues, antiseptic surgical dressings, etc., are also largely used, though not referred to in the Pharmacopœia.

1562. Ointments are usually soft solid fatty mixtures having a melting point near the temperature of the human body. They may be intended simply to render the skin soft and pliant, but are generally medicated with some substance intended either to be absorbed through the pores of the skin or to exert a local effect upon the parts to which they are applied.

The materials of which the fatty basis of ointments are pre-pared are: lard, mixtures of lard and wax, and other mixtures of fats and resinous matters. But glycerite of starch and soft soap are also used in a similar manner.

When solid fatty substances are to be mixed they are fused.

This insures an intimate intermixture. But when spermaceti, wax, or other solid fats of high melting point are to be incorporated with liquid fats, the solids being fused for this purpose, the liquid fats must also be warm and the mixture must be well stirred without interruption until cooled sufficiently to begin to thicken, for otherwise the firm fats of high melting point may congeal separately and render the product lumpy instead of smooth and uniform.

Brisk stirring of a fused ointment or fatty mixture during the process of cooling renders the product lighter in color, softer, and bulkier.

Ointments not made by fusion are prepared by trituration of the ingredients in a mortar, the medicament or active ingredient being mixed first with a small portion of the base or fat, and the remainder of the base added gradually. If the medicament is a solid it should be either finely powdered or dissolved in a small amount of a suitable solvent; but it is rarely practicable to dissolve the active constituent before incorporating it in the ointment as only a very limited amount of liquid can be added.

There are 23 official ointments.

1563. Cerates differ from ointments mainly as to their melting point and consistence. They do not melt at blood heat (37°C., or 98°F.), and are firmer than the ointments. Cerates are used as dressings. There are 6 official cerates.

1564. Plasters (*emplastra*) are generally firm, pliable, somewhat adhesive solids, of such consistence that they must be softened by heat or melted before they can be spread upon skin, muslin or paper. They are not adhesive except when warmed to the temperature of the body, and are applied locally to the skin, sometimes simply to exclude air and protect the surface covered, and sometimes to medicate.

"Adhesive plaster" is the resin plaster of the Pharmacopœia; that is used to close the lips of wounds, and in other ways as a general "sticking plaster." Plasters are made of lead oleate and other metallic oleates, resins, gum-resins, and wax. They

are sometimes described as of three different kinds: 1, plasters consisting mainly of metallic oleates, especially the oleate of lead; 2, resin plasters, like that of Burgundy pitch; 3, gum-resin plasters, like those of ammoniac and asafœtida.

But there are also plasters prepared from rubber.

Lead plaster consists mainly of oleate of lead, but contains also some stearate.

Plasters containing resins and gum-resins have stimulant qualities. But more active medicaments are often introduced into plasters, as narcotic extracts, etc. When a solid extract is to be mixed with a plaster, the plaster must be melted by moderate heat, as over a water-bath, and the solid extract, previously rubbed to a smooth, semi-fluid condition with dilute alcohol, is then stirred in thoroughly.

1565. Oleates of some metals, as lead, zinc, mercury, iron and copper, and oleates of some of the alkaloids, are employed externally as plasters or ointments.

They are usually prepared in one of two ways: by double decomposition between sodium oleate (Castile soap) and a salt of the metal or alkaloid, or by dissolving metallic oxides or alkaloids in oleic acid.

Some of the " oleates " employed are not pure, but the true oleates dissolved in or mixed with oleic acid or with fats.

1566. Suppositories are firm solids formed into long cones with flat base and rounded apex. They are usually made of oil of theobroma, medicated as may be required, and weigh from 15 to 30 grains (1 to 2 Grams).

The Pharmacopœia gives a general formula for the preparation of suppositories, directing that, unless otherwise prescribed by the physician, they shall be made of oil of theobroma and shall each weigh 1 Gram.

Oil of theobroma (or Cacao butter) is preferred because, while it is quite firm at ordinary temperatures, it melts rapidly at the temperature of the body.

Suppositories are used to introduce medicinal substances

into the rectum, urethra, or vagina, their size and form being modified according to their intended use.

The ingredients are mixed by trituration, and the cones are formed either by pressing the cold mass into moulds, or by melting the mass and pouring it into chilled moulds, or they are formed out of the cold mass by rolling, cutting and finishing them with the fingers.

But oil of theobroma is not the only base used for suppositories. Glyco-gelatin is also used; it is a mixture of gelatin, glycerin and water in such proportions that when the mass is allowed to cool, after having been made with the aid of water-bath heat, it has the required consistence and firmness.

Soap is also used in some suppository masses.

There are no suppositories named in the Pharmacopœia.

1567. Gargles (*gargarismata*) are washes for the throat. They are usually water solutions of astringent, antiseptic, or other medicaments.

1568. Lotions are washes for local external use, consisting of medicated watery liquids or solutions.

Eye washes are called *collyria*, and nasal lotions *collunaria*.

1569. Injections are water solutions or other watery fluids, medicated or not, which are to be injected by means of syringes into cavities, as the rectum, vagina, urethra, the ear, or the nose. An injection for the rectum is called an *enema*.

1570. Collodions are liquid external applications having for their base a solution of pyroxylin (or colloxylin) in a mixture of stronger ether and alcohol. By "pyroxylin" the Pharmacopœia designates "soluble gun-cotton," which is known also by the name of "photographer's gun-cotton."

Simple collodion is used to cover small surfaces or to close wounds, etc., instead of adhesive plaster and isinglass plaster. As the contraction caused by the ordinary collodion is sometimes painful, additions are made to it to prevent it. The Pharmacopœia has a "flexible collodion" containing castor oil and Canada turpentine to correct the difficulty referred to.

There are also two official medicated collodions—cantharidal collodion, used as a blistering application ; and styptic collodion, used as an astringent.

1571.   Liminents are liquid, oily or alcoholic preparations for external application with or without friction.

Fixed and volatile oils, and tinctures, fluid extracts and other alcoholic solutions are the most common ingredients employed.

There are nine different liniments in the Pharmacopœia.

1572.   The student is advised to study in the Pharmacopœia of the United States the simpler preparations for which working formulas are given in that work.   The Pharmacopœia in force since January 1st, 1894, is the Seventh Decennial Revision, which was published in the autumn of 1893.   A great number of changes were made in that revision so that our present Pharmacopœia is very different in many respects from any of its predecessors.

A copy of the Pharmacopœia [not an old one, but *the* Pharmacopœia now in effect] should be found in every drugstore, in every physician's office, and in the hands of every student of pharmacy.

CHAPTER LXXXIX.

THE LATINITY OF PHARMACEUTICAL NOMENCLATURE.

1573.   Technical terminology is a necessity in every branch of science and art and in every profession or trade. Special words, or terms, are necessary to express specific things and ideas, and for every new thing or new idea a new word must be assigned to represent it.   These technical terms are usually constructed out of words selected from unspoken or dead languages; but they may be otherwise coined.   The word

telephone was constructed to designate the valuable instrument which was only a few years ago undiscovered; if you did not now have that word "telephone," what would you call the instrument? It must have some name, and that name must be one which is not ambiguous; it must be sufficiently brief, and yet it must not be a word that has some other meaning than that which you want to impart to it. If we do not call the instrument a telephone, we must call it by some other equally new, suitable, unambiguous title. The same may be said of innumerable other technical terms, or words, or names. Technical terms are used in all branches of science, in law, in religion, in education, in the arts, in mechanics, in the trades, in medicine, in pharmacy. Numerous technical terms which are not only thoroughly understood but at the same time indispensable to the specialists who use them, are altogether unintelligible to others. The pharmacist knows what a percolator is, but very few others know it.

The words used to designate pharmaceutical processes, pharmaceutical apparatus and implements, drugs and preparations, and many other things pharmaceutical, are *technical terms*, and their construction and application constitute *technical terminology*.

1574. Latinic titles.—The titles and names given to drugs and preparations in the pharmacopœias of the different nations are derived from various sources. Many are derived from Greek words, others from Latin, Arabic, Hebrew, Spanish, French, English, German, the tongues of savage tribes in various parts of the world, the names of countries, cities and towns, the names of men, etc. All these various technical terms or titles, regardless of their origin, are given a latinic form or termination so far as this has been practicable, and all pharmaceutical titles not latinized or latinizable are indeclinable.

1575. About 500 different words are used in the construction of about 1,000 titles in the United States Pharmacopoeia·

Of these 500 words about 100 are simply modifications or derivatives of other words included in the 500, as, for instance, carboneum, carbonas, bicarbonas and subcarbonas from *Carbo*, sulphas, sulphis, subsulphas, tersulphas, hyposulphis, sulphidum, sulphuratus, bisulphas and bisulphidum from *sulphur*, etc.

The number of titles derived from Greek roots is greater than the number derived from Latin roots, and many titles have been coined out of several words from different languages.

Considerably less than one-third of all the substantive nouns used in the pharmacopoeial titles are of Latin origin, and very few of these are to be found in Latin dictionaries in the same form in which they are used in the pharmacopoeia: nomenclature. Moreover, the signification arbitrarily given to the words used as latinic pharmacopoeial titles of drugs chemicals and pharmaceutical preparations, is nearly always totally different, and not in any way discoverable, from the meaning of their roots. Hence, Latin scholars can not know or guess the meaning of the so-called "Latin titles" of medicinal substances; they must be mastered without any reference to Latin.

1576. To learn the construction of the pharmacopoeial nomenclature is not a very difficult task if the student will proceed in a systematic way. Much memorization is necessary, but there is a definite plan discoverable in the construction of the titles and this plan reduces greatly the tax upon the memory. Thus, for instance, the titles of nearly all inorganic chemicals are derived from the names of the comparatively few elements of which they are composed, and the titles of the galenical preparations are made up of the names of the drugs they represent or contain, together with the generic titles of the respective classes of preparations to which they belong.

1577. We shall now enumerate the words used in the pharmacopoeial and other latinic titles and afterwards the compound titles derived from them, classifying the titles and

words used as follows:—First the latinic names of the elements used, or entering into chemical compounds; second, the latinic generic names of whole groups of such compounds; third, the latinic specific titles of individual chemicals; fourth, the latinic titles of organic drugs; fifth, latinic names of plant organs, and classes of substances derived from plants; sixth, latinic generic titles of classes of pharmaceutical preparations; seventh, latinic specific titles of individual preparations; and eighth latinic adjectives used in connection with pharmaceutical nomenclature and terminology.

1578. By *generic titles* we mean general titles applicable to whole classes of substances. Thus *Pilulæ* is a generic title because there are several kinds of pills; *Radices* may also be said to constitute a general title because we use many different kinds of roots, which, for purposes of study, might be considered together in one group; *Nitras* is the generic title for each of the several nitrates. The generic titles, therefore, are used in the plural as well as the singular number.

By *specific titles* we mean those which apply, respectively, to single individual substances. These are of course used only in the singular. Thus, while *Tinctura* is a generic title because there are many kinds of tinctures, the title *Tinctura Hydrastis* is a specific title because there is but one such preparation recognized by the pharmacopoeïa and the title Hydrastis, too, is a specific title as we have but one drug by that name.

1579. The following are the names of the elements used in pharmacy or medicine or entering into the chemical compounds so used:—

ELEMENTS.

Latinic Name.

Nominative.	*Genitive.*	*English Name.*
Alu´minum	Alu´mini	Aluminum
Antimo´num	Antimo´ni	Antimony
Argen´tum	Argen´ti	Silver
Arse´num	Arse ni	Arsenic

A'urum	A'uri	Gold
Ba'rium	Ba'rii	Barium
Bismu'thum	Bismu'thi	Bismuth
Bo'rum	Bo'ri	Boron
Bro'mum	Bro'mi	Bromine
Cad'mium	Cad'mii	Cadmium
Cal'cium	Cal'cii	Calcium
Carbo'neum	Carbo'nei	Carbon
Ce'rium	Ce'rii	Cerium
Chlo'rum	Chlo'ri	Chlorine
Chro'mium	Chro'mii	Chromium
Cobal'tum	Cobal'ti	Cobalt
Cu'prum	Cu'pri	Copper
Fer'rum	Fer'ri	Iron
Hydrar'gyrum	Hydrar'gyri	Mercury
Hydroge'nium	Hydroge'nii	Hydrogen
Io'dum	Io'di	Iodine
Ka'lium	Ka'lii	Potassium
Li'thium	Li'thii	Lithium
Magne'sium	Magne'sii	Magnesia
Manga'num	Manga'ni	Manganese
Molyb'denum	Molyb'deni	Molybdenum
Na'trium	Na'trii	Sodium
Nic'colum	Nic'coli	Nickel
Nitroge'nium	Nitroge'nii	Nitrogen
Os'mium	Os'mii	Osmium
Oxyge'nium	Oxyge'nii	Oxygen
Phos'phorus	Phos'phori	Phosphorus
Plum'bum	Plum'bi	Lead
Potas'sium	Potas'sii	Potassium
Sili'cium	Sili'cii	Silicon
So'dium	So'dii	Sodium
Stan'num	Stan'ni	Tin
Sti'bium	Stib'ii	Antimony
Stron'tium	Stron'tii	Strontium
Sul'phur	Sul'phuris	Sulphur
Ura'nium	Ura'nii	Uranium
Zin'cum	Zin'ci	Zinc

The student will observe that the Latinic names all have the ending —*um* or —*ium* in the nominative and —*ii* or —*i* in the genitive with the sole exception of the name sulphur, gen. sulphuris.

The syllable to be accentuated in the pronunciation of the words is marked.

Potassium, Sodium and Antimony have also the names Kalium, Natrium and Stibium; but these names are not used in this country, nor in England.

1580. The latinic titles of *chemical compounds* are derived, as a rule, from the titles of the elements. Hence, the necessity of knowing the names of the elements before learning the names of the compounds.

In the construction of the titles of compounds the positive radical is indicated *first*, usually by the name of the positive radical (generally a metal) in the genitive, and the negative radical is indicated in the second half of the title. Thus we have Potassii Bromidum for Potassium Bromide, Potassii Sulphas for Potassium Sulphate, etc. [See par. 1588.]

The generic titles employed to designate classes of chemical compounds are derived from the negative element in binary compounds, or from the principal element characterizing the negative radical (if compound).

Thus the title Bromidum, bromide, is derived from Bromum; Chloridum, chloride, from Chlorum; Iodidum, iodide, from Iodum; Oxidum, oxide, from Oxygenium; Phosphidum, phosphide, from Phosphorus; and Sulphidum, sulphide, from Sulphur.

In naming true salts we get: Arsenas and Arsenis, for arsenate and arsenite, from Arsenum; Carbonas, for carbonate, from Carboneum; Chloras, for chlorate, from Chlorum; Nitras and Nitris, for nitrate and nitrite, from Nitrogenium or its root; Phosphas, for phosphate, from Phosphorus; and Sulphas and Sulphis, for sulphate and sulphite, from Sulphur. This is abundantly illustrated in paragraph 1588.

When these derivatives are not sufficient it is necessary to employ prefixes as in Bicarbonas, Hypophosphis, Subsulphas, and Permanganas, or such compound words as Ferrocyanidum, Thiosulphas, etc.

Compare these statements with the chapter on chemical nomenclature in part II of this book.

1581. The latinic generic titles ending in —*idum* are generally those of binary compounds having English names

ending in —*ide*. In other words, to latinize the English technical title of a compound the name of which ends in —*ide*, it is only necessary to change the final —*e* to —*um*; thus chloride becomes chloridum, oxide is changed to oxidum, sulphide to sulphidum, etc., as the following examples will show:—

Latinic Name.

Nominative.	*Genitive.*	*English Name.*
Bro'midum	Bro'midi	Bromide
Chlo'ridum	Chlo'ridi	Chloride
Cya'nidum	Cya'nidi	Cyanide
Ferricya'nidum	Ferricya'nidi	Ferricyanide
Ferrocya'nidum	Ferrocya'nidi	Ferrocyanide
Ox'idum	Ox'idi	Oxide
Phos'phidum	Phos'phidi	Phosphide
Sulp'hidum	Sul'phidi	Sulphide
Monobro'midum	Monobro'midi	Monobromide
Diox'idum	Diox'idi	Dioxide
Trichlo'ridum	Trichlo'ridi	Trichloride

The titles Acidum, Anhydridum and Hydroxidum have the same form and follow the same declension as the foregoing:—

A'cidum	A'cidi	Acid
Anhy'dridum	Anhy'dridi	Anhydride
Hydrox'idum	Hydrox'idi	Hydroxide

1582. The latinic generic chemical titles ending in —*as* are those that designate "—*ic* salts", or the salts of "—*ic*" acids, or, in other words, they belong to the compounds having English names ending in —*ate*. Therefore, to latinize an English chemical title ending in —*ate* it is only necessary to change that ending to —*as*. Thus sulphate becomes sulphas, nitrate is changed to nitras, acetate to acetas, carbonate to carbonas, etc., as will be seen from the following examples:—

Latinic Name.

Nominative.	*Genitive.*	*English Name.*
Antimo'nas	Antimona'tis	Antimonate
Arse'nas	Arsena'tis	Arsenate
Bo'ras	Bora'tis	Borate
Bibor'as	Bibora'tis	Biborate
Bro'mas	Broma'tis	Bromate

Carbo'nas	Carbona'tis	Carbonate
Bicarbo nas	Bicarbona'tis	Bicarbonate
Subcarbo'nas	Subcarbona'tis	Subcarbonate
Chlo'ras	Chlora'tis	Chlorate
Chro'mas	Chroma'tis	Chromate
Bichro'mas	Bichroma'tis	Bichromate
Dichro'mas	Dichroma'tis	Dichromate
Hy'dras	Hydra'tis	Hydrate
Io'das	Ioda'tis	Iodate
Manga'nas	Mangana'tis	Manganate
Permanga'nas	Permangana'tis	Permanganate
Molyb'das	Molybda'tis	Molybdate
Ni'tras	Nitra'tis	Nitrate
Snbni'tras	Subnitra'tis	Subnitrate
Phos'phas	Phospha'tis	Phosphate
Orthophos'phas	Orthophospha'tis	Orthophosphate
Pyrophos'phas	Pyrophospha'tis	Pyrophosphate
Metaphos'phas	Metaphospha'tis	Metaphosphate
Si'licas	Silica'tis	Silicate
Stan'nas	Stanna'tis	Stannate
Sul'phas	Sulpha'tis	Sulphate
Bisul'phas	Bisulpha'tis	Bisulphate
Subsul'phas	Subsulpha'tis	Subsulphate
Tersul'phas	Tersulpha'tis	Tersulphate
———	———	———
Lactophos'phas	Lactophospha'tis	Lactophosphate
Sulphocarbo'las	Sulphocarbola'tis	Sulphocarbolate
Phenysulpho'nas	Phenylsulponha'tis	Phenylsulphonate
———	———	———
Hydrobro'mas	Hydrobroma'tis	Hydrobromate
Hydrochlo'ras	Hydrochlora'tis	Hydrochlorate
Hydrio'das	Hydrioda'tis	Hydriodate
———	———	———
Ace'tas	Aceta'tis	Acetate
Subace'tas	Subaceta'tis	Subacetate
Ben'zoas	Benzoa'tis	Benzoate
Ci'tras	Citra'tis	Citrate
Lac'tas	Lactat'is	Lactate
O'leas	Olea'tis	Oleate
Ox'alas	Oxala'tis	Oxalate
Pi'cras	Picra'tis	Picrate
Salicy'las	Salicyla'tis	Salicylate
Santoni'nas	Santonina'tis	Santoninate
Tan'nas	Tanna'tis	Tannate
Tar'tras	Tartra'tis	Tartrate
Bitar'tras	Bitartra'tis	Bitartrate
———	———	———

1583. Latinic generic titles of chemicals when ending in—*is* correspond to the English chemical titles ending in —*ite*. They

are therefore the generic titles of salts formed by the so-called
"—ous acids". To latinize the English titles ending in —*ite*,
that ending is simply changed to —*is*. Thus hypophosphite is
changed to hypophosphis, the latinic form of bisulphite is bi-
sulphis, that of arsenite is arsenis, etc.

The following examples are familiar:—

Latinic Titles.

Nominative.	*Genitive.*	*English Titles.*
Arse´nis	Arseni´tis	Arsenite
Ni´tris	Nitri´tis	Nitrite
Phos´phis	Phosphi´tis	Phosphite
Hypophos´phis	Hypophosphi´tis	Hypophosphite
Sul´phis	Sulphi´tis	Sulphite
Bisul´phis	Bisulphi´tis	Bisulphite
Hyposul´phis	Hyposulphi´tis	Hyposulphite

1584. The following latinic titles of chemical compounds
are unsystematic and are, therefore placed in a group by them-
selves.

Latinic Titles

Nominative	*Genitive.*	*English Titles.*
A´qua	A´quæ	Water
Ammo´nia	Ammo´niæ	Ammonia
Magne´sia	Magne´siæ	Magnesia
Potas´sa	Potas´sæ	Potassa
So´da	So´dæ	Soda
Potas´sa cum Cal´ce	Potas´sæ cum Cal´ce	Potassa with Lime
Cre´ta	Cre´tæ	Chalk
Ammo´nium	Ammo´nii	Ammonia
Lithar´gyrum	Lithar´gyri	Litharge
Ca´lx	Cal´cis	Lime
Alu´men	Alu´minis	Alum
Ae´ther	Ae´theris	Ether
Ca´lomel	Calomela´nos	Calomel .

1585. Neutral principles extracted from plant drugs re-
ceive English names ending with —*in* and these names are lat-

inized by simply adding —*um* making the ending —*inum*. Ex˙ Salicin is latinized to salicinum, aloin to aloinum, etc.

There are also many other substances having English titles which end with —*in* and are treated in the same manner as the titles of neutral principles when latinized.

In the following list have been included also a number of other products having latinic titles ending in —*um* as all of these titles follow the second declension, (1592).

Latinic Titles.

Nominative.	*Genitive.*	*English Titles.*
Acetanili'dum	Acetanili'di	Acetanilide
Aceto'num	Aceto'ni	Acetone
Agarici'num	Agarici'ni	Agaricin
Aldehy'dum	Aldehy'di	Aldehyde
Aloi'num	Aloi'ni	Aloin
Amygdali'num	Amygdali'ni	Amygdalin
Antifebri'num	Antifebri'ni	Antifebrin
Benzi'num	Benzi'ni	Benzin
Boroglyceri'num	Boroglycer'ni	Boroglycerin
Bromofor'mum	Bromofor'mi	Bromoform
Chlo'ralami'dum	Chlo'ralami'di	Chloralamide
Chrysarobi'num	Chrysarobi'ni	Chrysarobin
Creoso'tum	Creoso'ti	Creosote
Elateri'num	Elateri'ni	Elaterin
Glonoi'num	Glonoi'ni	Glonoin
Glyceri'num	Glyceri'ni	Glycerin
Glycyrrhizi'num	Glycyrrhizi'ni	Glycyrrhizin
Iodofor'mum	Iodofor'mi	Iodoform
Naphtali'num	Naphtali'ni	Naphtalin
Nitroglyceri'num	Nitroglyceri'ni	Nitroglycerin
Pancreati'num	Pancreati'ni	Pancreatin
Paraldehy'dum	Paraldehy'di	Paraldehyde
Pepsi'num	Pepsi'ni	Pepsin
Phenaceti'num	Phenaceti'ni	Phenacetin
Phlorizi'num	Phlorizi'ni	Phlorizin
Picrotoxi'num	Picrotoxi'ni	Picrotoxin
Piperi'num	Piperi'ni	Piperin
Populi'num	Populi'ni	Populin
Pyroxyli'num	Pyroxyli'ni	Pyroxylin
Resorci'num	Resorci'ni	Resorcin
Salici'num	Salici'ni	Salicin
Santoni'num	Santoni'ni	Santonin
Terebe'num	Terebe'ni	Terebene
Terpi'num	Terpi'ni	Terpin
Uretha'num	Uretha'ni	Urethane

1586. Alkaloids and other organic bases receive English names ending in —*ine*, and these names are latinized by changing the final letter from *e* to *a*. The latinic titles of all alkaloids, therefore, end in —*ina*. Thus strychnine is called *strychnina* in the latinic nomenclature; the English title morphine is latinized to *morphina*, etc.

A list of 41 important alkaloids is here presented.

Latinic Titles.

Nominative.	*Genitive.*	*English Titles.*
Aconiti'na	Aconiti'næ	Aconitine
Anili'na	Anili'næ	Aniline
Antipyri'na	Antipyri'næ	Antipyrine
Apomorphi'na	Apomorphi'næ	Apomorphine
Aspidospermi'na	Aspidospermi'næ	Aspidospermine
Atropi'na	Atropi'næ	Atropine
Berberi'na	Berberi'næ	Berberine
Bruci'na	Bruci'næ	Brucine
Buxi'na	Buxi'næ	Buxine
Caffei'na	Caffei'næ	Caffeine
Chelidoni'na	Chelidoni'næ	Chelidonine
Chinoli'na	Chinoli'næ	Chinoline
Cinchonidi'na	Cinchonidi'næ	Cinchonidine
Cinchoni'na	Cinchoni'næ	Cinchonine
Cocai'na	Cocai'næ	Cocaine
Codei'na	Codei'næ	Codeine
Colchici'na	Colchici'næ	Colchicine
Conii'na	Conii'næ	Coniine
Emeti'na	Emeti'næ	Emetine
Gelsemi'na	Gelsemi'næ	Gelsemine
Homatropi'na	Homatropi'næ	Homatropine
Hydrasti'na	Hydrasti'næ	Hydrastine
Hydrastini'na	Hydrastini'næ	Hydrastinine
Hyosci'na	Hyosci'næ	Hyoscine
Hyoscyami'na	Hyoscyami'næ	. Hyoscyamine
Jervi'na	Jervi'næ	Jervine
Lobeli'na	Lobeli'næ	Lobeline
Morphi'na	Morphi'næ	Morphine
Narcoti'na	Narcoti'næ	Narcotine
Nicoti'na	Nicoti'næ	Nicotine
Pelletieri'na	Pelletieri'næ	Pelletierine
Physostigmi'na	Physostigmi'næ	Physostigmine
Pilocarpi'na	Pilocarpi'næ	Pilocarpine
Piperazi'na	Piperazi'næ	Piperazine
Pyridi'na	Pyridi'næ	Pyridine
Quinidi'na	Quinidi'næ	Quinidine
Quini'na	Quini'næ	Quinine
Sanguinari'na	Sanguinari'næ	Sanguinarine

Spartei´na	Spartei´næ	Sparteine
Strychni´na	Strychni´næ	Strychnine
Veratri´na	Veratri´næ	Veratrine

1587. Organic positive hydrocarbon radicals receiving English technical names ending in—*yl,* as ethyl, methyl, etc., remain unchanged in the latinic nomenclature, and are treated as indeclinable words. In other words, their English and latinic titles are identical, and their genitives are identical with their nominatives. If the English title be amyl the latinic title is also amyl, and its genitive amyl.

The titles ending in —*yl* are exemplified by amyl, æthyl, (English *ethyl,*) butyl, formyl, glyceryl, methyl, phenyl.

Certain alcohols and other substances having English names ending in —*ol* follow the same rule, i. e.,their latinic titles are the same as the English ones and are indeclinable. Thus we have: alcohol, apiol, aristol, aseptol, betol, eucalyptol, guaiacol, ichtyol, iodol, menthol, myrtol, naphtol, phenol, pyrogallol, salol, terpinol, thiol and thymol.

Some aldehydes, aldehyde-derivatives, and other compounds have received English titles ending in —*al,* and the latinic titles of these are also identical with the English names and indeclinable. Among them are: bromal, chloral, methylal, pental, sulphonal.

1588. The compound latinic titles of individual chemical compounds usually consist of two words—one a specific title referring to the positive radical and the other a generic title referring to the negative radical and indicating the class to which the compound belongs. There are however exceptions to this rule as will be seen in paragraph 1589. Some compound titles of chemicals are made up of a substantive noun designating the class to which the chemical compound belongs and an adjective referring to the radical which specifies the individual substance named, as is the case with all acids (1590).

The titles of individual binary compounds and salts are made

up of the words already enumerated in paragraphs 1579, 1580, 1581, 1582, 1583, 1586 and the positive hydrocarbon radicals mentioned in 1587.

The following examples will suffice to illustrate the system upon which these compound titles are constructed:—

Latinic Titles.

Nominative.	Genitive.	English Titles
Antimo'ni Ox'idum	Antimo'ni Ox'idi	Antimony Oxide
Argen'ti Ox'idum	Argen'ti Ox'idi	Silver Oxide
Ba'rii Diox'idum	Ba'rii Diox'idi	Barium Dioxide
Cal'cii Oxi'dum	Cal'cii Ox'idi	Calcium Oxide
Hydrar'gyri Ox'idum	Hydrar'gyri Oxidi	Oxide of Mercury
Magne'sii Ox'idum	Magne'sii Ox'idi	Magnesium Oxide
Manga'ni Ox'idum	Manga'ni Oxidi	Manganese Oxide
Plum'bi Ox'idum	Plum'bi Ox'idi	Lead Oxide
Zin'ci Ox'idum	Zin'ci Ox'idi	Zinc Oxide
—	—	—
Antimo'ni Sul'phidum	Antimo'ni Sul'phidi	Antimony Sulphide
Ba'rii Sul'phidum	Ba'rii Sul'phidi	Barium Sulphide
Cal'cii Sul'phidum	Cal'cii Sul'phidi	Calcium Sulphide
Carbo'nei Disul'phidum	Carbo'nei Disul'phidi	Carbon Disulphide
Hydrar'gyri Sul'phidum	Hydrar'gyri Sulphidi	Mercury Sulphide
—	—	—
Ammo'nii Chlo'ridum	Ammo'nii Chloridi	Ammonium Chloride
A'uri Chlo'ridum	A'uri Chlo'ridi	Gold Chloride
Ba'rii Chlo'ridum	Bar'ii Chlo'ridi	Barium Chloride
Cal'cii Chlo'ridum	Cal'cii Chlo'ridi	Calcium Chloride
Fer'ri Chlo'ridum	Fer'ri Chlo'ridi	Iron Chloride
Hydrar'gyri Chlo'ridum	Hydrar'gyri Chlo'ridi	Mercury Chloride
Li'thii Chlo'ridum	Li'thii Chlo'ridi	Lithium Chloride
Magne'sii Chlo'ridum	Magne'sii Chlo'ridi	Magnesium Chloride
Potas'sii Chlo'ridum	Potas'sii Chlo'ridi	Potassium Chloride
So'dii Chlo'ridum	So'dii Chlo'ridi	Sodium Chloride
Stron'til Chlo'ridum	Stron'tii Chlo'ridi	Strontium Chloride
Zin'ci Chlo'rfdum	Zin'ci Chlo'ridi	Zinc Chloride
—	—	—
Ammo'nii Bro'midum	Ammo'nii Bro'midi	Ammonium Bromide
Cal'cii Bro'midum	Cal'cii Bro'midi	Calcium Bromide
Li'thii Bro'midum	Li'thii Bro'midi	Lithium Bromide
Potas'sii Bro'midum	Potas'sii Bro'midi	Potassium Bromide
So'dii Bro'midum	So'dii Bro'midi	Sodium Bromide
—	—	—
Ammo'nii Io'didum	Ammo'nii Io'didi	Ammonium Iodide
Argen'ti Io'didum	Argen'ti Io'didi	Silver Iodide
Arse'ni Io'didum	Arse'ni Io'didi	Arsenic Iodide
Cad'mii Io'didum	Cad'mii Io'didi	Cadmium Iodide
Cal'cii Io'didum	Cal'cii Io'didi	Calcium Iodide

Fer'ri Io'didum	Fer'ri Io'didi	Iron Iodide
Hydrar'gyri Io'didum	Hydrar'gyri Io'didi	Mercury Iodide
Li'thii Io'didum	Li'thii Io'didi	Lithium Iodide
Plum'bii Io'didum	Plumb'i Io'didi	Lead Iodide
Potas'sii Io'didum	Potas'sii Io'didi	Potassium Iodide
So'dii Io'didum	So'dii Io'didi	Sodium Iodide
Stron'tii Io'didum	Stron'tii Io'didi	Strontium Iodide
Sul'phuris Io'didum	Sul'phuris Io'didi	Sulphur Iodide
Argen'ti Cya'nidum	Argen'ti Cya'nidi	Silver Cyanide
Hydrar'gyri Cya'nidum	Hydrar'gyri Cya'nidi	Mercury Cyanide
Potas'sii Cya'nidum	Potas'sii Cya'nidi	Potassium Cyanide
Potas'sii Ferrocya'nidum	Potas'sii Ferrocya'nidi	Potassium Ferrocyanide
Potas'sii Antimo'nas	Potas'sii Antimona'tis	Potassium Antimonate
Fer'ri Arse'nas	Fer'ri Arsena'tis	Iron Arsenate
So'dii Arse'nas	So'dii Arsena'tis	Sodium Arsenate
So'dii Bo'ras	So'dii Bora'tis	Sodium Borate
Ammo'nii Carbo'nas	Ammo'nii Carbona'tis	Ammonium Carbonate
Cal'cii Carbo'nas	Cal'cii Carbona'tis	Calcium Carbonate
Fer'ri Carbo'nas	Fer'ri Carbona'tis	Iron Carbonate
Li'thii Carbo'nas	Li'thii Carbona'tis	Lithium Carbonate
Magne'sii Carbo'nas	Magne'sii Carbona'tis	Magnesium Carbonate
Plum'bi Carbo'nas	Plum'bi Carbona'tis	Lead Carbonate
Potas'sii Carbo'nas	Potas'sii Carbona'tis	Potassium Carbonate
So'dii Carbo'nas	So'dii Carbona'tis	Sodium Carbonate
Zin'ci Carbo'nas	Zin'ci Carbona'tis	Zinc Carbonate
Potas'sii Bicarbo'nas	Potas'sii Bicarbona'tis	Potassium Bicarbonate
So'dii Bicarbo'nas	So'dii Bicarbona'tis	Sodium Bicarbonate
Bismu'thi Subcarbo'nas	Bismu'thi Subcarbona'tis	Bismuth Subcarbonate
Potas'sii Chlo'ras	Potas'sii Chlora'tis	Potassium Chlorate
So'dii Chlo'ras	So'dii Chlora'tis	Sodium Chlorate
Potas'sii Dichro'mas	Potas'sii Dichroma'tis	Potassium Dichromate
Alu'mini Hy'dras	Alu'mini Hydra'tis	Aluminum Hydrate
Potas'sii Permanga'nas	Potas'sii Permangana'tis	Potassium Permanganate
Ammo'nii Nitras	Ammo'nii Nitratis	Ammonium Nitrate
Argen'ti Nitras	Argen'ti Nitratis	Silver Nitrate
Bar'ii Ni'tras	Bar'ii Ni'tratis	Barium Nitrate
Bismu'thi Nitras	Bismu'thi Nitra'tis	Bismuth Nitrate
Bismu'thi Subni'tras	Bismu'thi Subnitra'tis	Bismuth Subnitrate
Cu'pri Ni'tras	Cu'pri Nitra'tis	Copper Nitrate
Fer'ri Ni'tras	Fer'ri Nitra'tis	Iron Nitrate
Hydrar'gyri Ni'tras	Hydrar'gyri Nitra'tis	Mercury Nitrate

Plum'bi Ni'tras	Plum'bi Nitra'tis	Lead Nitrate
Potas'sii Ni'tras	Potas'sii Nitra'tis	Potassium Nitrate
Sod'ii Ni'tras	Sod'ii Nitra'tis	Sodium Nitrate
Stron'tii Ni'tras	Stron'tii Nitra'tis	Strontium Nitrate

Ammo'nii Phos'phas	Ammo'nii Phospha'tis	Ammonium Phosphate
Cal'cii Phos'phas	Cal'cii Phospha'tis	Calcium Phosphate
Fer'ri Phos'phas	Fer'ri Phospha'tis	Iron Phosphate
Potas'sii Phos'phas	Potas'sii Phospha'tis	Potassium Phosphate
So'dii Phos'phas	So'dii Phospha'tis	Sodium Phosphate

Fer'ri Pyrophos'phas	Fer'ri Pyrophospha'tis	Iron Pyrophosphate
So'dii Pyrophos'phas	So'dii Pyrophospha'tis	Sodium Pyrophosphate

So'dii Si'licas	So'dii Silica'tis	Sodium Silicate

Alu'mini Sul'phas	Alu'mini Sulpha'tis	Aluminum Sulphate
Ammo'nii Sul'phas	Ammo'nii Sulpha'tis	Ammonium Sulphate
Cad'mii Sul'phas	Cad'mii Sulpha'tis	Cadmium Sulphate
Cal'cii Sul'phas	Cal'cii Sulpha'tis	Calcium Sulphate
Cu'pri Sul'phas	Cu'pri Sulpha'tis	Copper Sulphate
Fer'ri Sul'phas	Fer'ri Sulpha'tis	Iron Sulphate
Fer'ri Subsul'phas	Fer'ri Subsulpha'tis	Iron Subsulphate
Fer'ri Tersul'phas	Fer'ri Tersulpha'tis	Iron Tersulphate
Hydrar'gyri Sul'phas	Hydrar'gyri Sulpha'tis	Mercury Sulphate
Hydrar'gyri Subsul'phas	Hydrar'gyri Subsulpha'tis	Mercury Subsulphate
Magne'sii Sul'phas	Magnes'ii Sulpha'tis	Magnesium Sulphate
Mangan'i Sul'phas	Mangan'i Sulpha'tis	Manganese Sulphate
Potas'sii Sul'phas	Potas'sii Sulpha'tis	Potassium Sulphate
So'dii Sul'phas	So'dii Sulpha'tis	Sodium Sulphate
Zinc'i Sul'phas	Zinc'i Sulpha'tis	Zinc Sulphate

Cal'cii Lactophos'phas	Cal'cii Lactophospha'tis	Calcium Lactophosphate
So'dii Sulphocarbo'las	So'dii Sulphocarbola'tis	Sodium Sulphocarbolate
Zinc'i Sulphocarbo'las	Zinc'i Sulphocarbola'tis	Zinc Sulphocarbolate

Ammo'nii Ace'tas	Ammo'nii Aceta'tis	Ammonium Acetate
Cu'pri Ace'tas	Cu'pri Aceta'tis	Copper Acetate
Fer'ri Ace'tas	Fer'ri Aceta'tis	Iron Acetate
Plum'bi Subace'tas	Plum'bi Subaceta'tis	Lead Subacetate
Plum'bi Ace'tas	Plum'bi Aceta'tis	Lead Acetate
Potas'sii Ace'tas	Potas'sii Aceta'tis	Potassium Acetate
So'dii Ace'tas	So'dii Aceta'tis	Sodium Acetate
Zinc'i Ace'tas	Zin'ci Aceta'tis	Zinc Acetate

Ammo'nii Ben'zoas	Ammo'nii Benzoa'tis	Ammonium Benzoate
Li'thii Ben'zoas	Li'thii Benzoa'tis	Lithium Benzoate
So'dii Ben'zoas	So'dii Benzoa'tis	Sodium Benzoate

Ammo'nii Ci'tras	Ammo'nii Citra'tis	Ammonium Citrate
Bismu'thi Ci'tras	Bismu'thi Citra'tis	Bismuth Citrate

Fer'ri Ci'tras	Fer'ri Citra'tis	Iron Citrate
Magne'sii Ci'tras	Magne'sii Citra'tis	Magnesium Citrate
Potas'sii Ci'tras	Potas'sii Citra'tis	Potassium Citrate
So'dii Ci'tras	So'dii Citra'tis	Sodium Citrate
Fer'ri Lac'tas	Fer'ri Lacta'tis	Iron Lactate
Zin'ci Lactas	Zin'ci Lacta'tis	Zinc Lactate
Potas'sii O'leas	Potas'sii Olea'tis	Potassium Oleate
Sod'ii O'leas	So'dii Olea'tis	Sodium Oleate
Ammo'nii Ox'alas	Ammo'nii Oxala'tis	Ammonium Oxalate
Ce'rii Ox'alas	Ce'rii Oxala'tis	Cerium Oxalate
Fer'ri Ox'alas	Fer'ri Oxala'tis	Iron Oxalate
Potas'sii Ox'alas	Potas'sii Oxala'tis	Potassium Oxalate
So'dii Ox'alas	So'dii Oxala'tis	Sodium Oxalate
Ammo'nii Pi'cras	Ammo'nii Picra'tis	Ammonium Picrate
Bismu'thi Salicy'las	Bismu'thi Salicyla'tis	Bismuth Salicylate
Li'thii Salicy'las	Li'thii Salicyla'tis	Lithium Salicylate
Potas'sii Salicy'las	Potas'sii Salicyla'tis	Potassium Salicylate
So'dii Salicy'las	So'dii Salicyla'tis	Sodium Salicylate
So'dii Santoni'nas	So'dii Santonina'tis	Sodium Santoninate
Bismu'thi Tan'nas	Bismu'thi Tanna'tis	Bismuth Tannate
Ammo'nii Tar'tras	Ammo'nii Tartra'tis	Ammonium Tartrate
Antimo'ni Tar'tras	Antimo'ni Tartra'tis	Antimony Tartrate
Fer'ri Tar'tras	Fer'ri Tartra'tis	Iron Tartrate
Potas'sii Tar'tras	Potas'sii Tartra'tis	Potassium Tartrate
Potas'sii Bitar'tras	Potas'sii Bitartra'tis	Potassium Bitartrate
So'dii Tar'tras	So'dii Tartra'tis	Sodium Tartrate
Potas'siiA rsenis	Potas'sii Arseni'tis	Potassium Arsenite
So'dii Ni'tris	So'dii Nitri'tis	Sodium Nitrite
Cal'cii Hypophos'phis	Cal'cii Hypophosphi'tis	Calcium Hypophosphite
Fer'ri Hypophos'phis	Fer'ri Hypophosphi'tis	Iron Hypophosphite
Potas'sii Hypophos'phis	Potas's̗ii Hypophosphi'tis	Potassium Hypophosphite
So'dii Hypophos'phis	So'dii Hypophosphi'tis	Sodium Hypophosphite
Cal'cii Sul'phis	Cal'cii Sulphi'tis	Calcium Sulphite
Magne'sii Sul'phis	Magne'sii Sulphi'tis	Magnesium Sulphite
So'dii Sul'phis	So'dii Sulphi'tis	Sodium Sulphite
So'dii Hyposul'phis	So'dii Hyposulphi'tis	Sodium Hyposulphite
Apomorphi'næ Hydrochlo'ras	Apomorphi'næ Hydrochlora'tis	Apomorphine Hydrochlorate

Atropi'næ Sul'phas	Atropi'næ Sulpha'tis	Atropine Sulphate
Chinoli'næ Tar'tras	Chinoli'næ Tartra'tis	Chinoline Tartrate
Cinchonidi'næ Sul'phas	Cinchonidi'næ Sulpha'tis	Cinchonidine Sulphate
Cinchonidi'næ Salicy'las	Cinchonidi'næ Salicyla'tis	Cinchonidine Salicylate
Cinchoni'næ Sul'phas	Cinchoni'næ Sulpha'tis	Cinchonine Sulphate
Cocai'næ Hydrochlo'ras	Cocai'næ Hydrochlora'tis	Cocaine Hydrochlorate
Homatropi'næ Hydrobro'mas	Homatropi'næ Hydrobroma'tis	Homatropine Hydrobromate
Hydrastini'næ Hydrochlo'ras	Hydrastini'næ Hydrochlora'tis	Hydrastinine Hydrochlorate
Hyosci'næ Hydrobro'mas	Hyosci'næ Hydrobroma'tis	Hyoscine Hydrobromate
Hyoscyami'næ Hydrobro'mas	Hyoscyami'næ Hydrobrma'tis	Hyoscyamine Hydrobromate
Hyoscyami'næ Sul'phas	Hyoscyami'næ Sulpha'tis	Hyoscyamine Sulphate
Morphi'næ Ace'tas	Morphi'næ Aceta'tis	Morphine Acetate
Morphi'næ Hydrochlo'ras	Morphi'næ Hydrochlora'tis	Morphine Hydrochlorate
Morphi'næ Su'lphas	Morphi'næ Sulpha'tis	Morphine Sulphate
Pelletieri'næ Tan'nas	Pelletieri'næ Tanna'tis	Pelletierine Tannate
Physostigmi'næ Salicy'las	Physostigmi'næ Salicyla'tis	Physostigmine Salicylate
Physostigmi'næ Sul'phas	Physostigmi'næ Sulpha'tis	Physostigmine Sulphate
Pilocarpi'næ Hydrochlo'ras	Pilocarpi'næ Hydrochlora'tis	Pilocarpine Hydrochlorate
Quinidi'næ Sul'phas	Quinidi'næ Sulpha'tis	Quinidine Sulphate
Quini'næ Bisul'phas	Quini'næ Bisulpha'tis	Quinine Bisulphate
Quini'næ Hydrobro'mas	Quini'næ Hydrobroma'tis	Quinine Hydrobromate
Quini'næ Hydrochlo'ras	Quini'næ Hydrochlora'tis	Quinine Hydrochlorate
Quini'næ Salicy'las	Quini'næ Salicyla'tis	Quinine Salicylate
Quini'næ Sul'phas	Quini'næ Sulpha'tis	Quinine Sulphate
Quini'næ Valeria'nas	Quini'næ Valeriana'tis	Quinine Valerianate
Spartei'næ Sul'phas	Spartei'næ Sulpha'tis	Sparteine Sulphate
Strychni'næ Ace'tas	Strychnin'æ Aceta'tis	Strychnine Acetate
Strychni'næ Ni'tras	Strychnin'æ Nitra'tis	Strychnine Nitrate
Strychni'næ Sul'phas	Strychni'næ Sulpha'tis	Strychnine Sulphate
A'myl Ni'tris	A'myl Nitri'tis	Amyl Nitrite
Ae'thyl Chlo'ridum	Ae'thyl Chlo'ridi	Ethyl Chloride
Me'thyl Salicy'las	Me'thyl Salicyla'tis	Methyl Salicylate
Gly'ceryl Bo'ras	Gly'ceryl Bora'tis	Glyceryl Borate
Terpi'ni Hy'dras	Terpi'ni Hydra'tis	Terpin Hydrate

1589. Double salts and other chemical compounds or even mixtures containing more than one positive radical (or base) are named on the same general plan as other salts, both radicals being named and connected by the word *et*, " and." Thus:—

Latinic Titles.

Nominative.	*Genitive.*	*English Titles.*
Antimo'ni et Potas'sii Tar'tras	Antimo'nf et Potas'sii Tartra'tis	Antimony-Potassium Tartrate

A'uri et So'dii Chlo'ridum	A'uri et So'dii Chlo'ridi	Gold-Sodium Chloride
Bismu'thi et Ammo'nii Ci'tras	Bismu'thi et Ammo'nii Citra'tis	Bismuth-Ammonium Citrate
Fer'ri et Ammo'nii Ci'tras	Fer'ri et Ammo'nii Citra'tis	Iron-Ammonium Citrate
Fer'ri et Ammo'nii Sul'phas	Fer'ri et Ammo'nii Sulpha'tis	Iron-Ammonium Sulphate
Fer'ri et Ammo'nii Tar'tras	Fer'ri et Ammo'nii Tartra'tis	Iron-Ammonium Tartrate
Fer'ri et Potas'sii Tar'tras	Fer'ri et Potas'sii Tartra'tis	Iron-Potassium Tartrate
Fer'ri et Quini'næ Ci'tras	Fer'ri et Quini'næ Citra'tis	Iron-Quinine Citrate
Fer'ri et Strychni'næ Ci'tras	Fer'ri et Strychni'næ Citra'tis	Iron-Strychnine Citrate
Potas'sii et So'dii Tar'tras	Potas'sii et So'dii Tartra'tis	Potassium-Sodium Tartrate

1590. The Latinic titles of the acids are exemplified as follows:—

Latinic Titles.

Nominative.	Genitive.	English Titles.
A'cidum	A'cidi	Acid
A'cidum Ace'ticum	A'cidi Aceti'ci	Acetic Acid
A'cidum Ace'ticum Dilu'tum	A'cidi Aceti'ci Dilu'ti	Diluted Acetic Acid
A'cidum Ace'ticum Glacia'le	A'cidi Aceti'ci Glacia'lis	Glacial Acetic Acid
A'cidum Arseno'sum	A'cidi Arseno'si	Arsenous Acid
A'cidum Benzo'icum	A'cidi Benzo'ici	Benzoic Acid
A'cidum Bo'ricum	A'cidi Bo'rici	Boric Acid
A'cidum Carbo'licum	A'cidi Carbo'lici	Carbolic Acid
A'cidum Carbo'licum Cru'dum	Acidi Carbolici Crudi	Crude Carbolic Acid
A'cidum Chro'micum	A'cidi Chro'mici	Chromic Acid
A'cidum Ci'tricum	A'cidi Ci'trici	Citric Acid
A'cidum Gal'licum	A'cidi Gal'lici	Gallic Acid
A'cidum Hydrio'dicum	A'cidi Hydrio'dici	Hydriodic Acid
A'cidum Hydrobrom'icum Dilu'tum	A'cidi Hydrobro'mici Dilu'ti	Diluted Hydrobromic Acid
A'cidum Hydrochlo'ricum	A'cidi Hydrochlo'rici	Hydrochloric Acid
A'cidum Hydrochlo'ricum Dilu'tum	A'cidi Hydrochlo'rici Dilu'ti	Diluted Hydrochloric Acid
A'cidum Hydrocya'nicum Dilu'tum	A'cidi Hydrocya'nici Dilu'ti	Diluted Hydrocyanic Acid
A'cidum Hypophosphoro'sum Dilu'tum	A'cidi Hypophosphoro'si Dilu'ti	Diluted Hypophosphorous A'cid
A'cidum Lac'ticum	A'cidi Lac'tici	Lactic Acid
A'cidum Ni'tricum	A'cidi Ni'trici	Nitric Acid
A'cidum Ni'tricum Dilu'tum	A'cidi Ni'trici Di'luti	Diluted Nitric Acid
A'cidum Nitrohydrochlo'ricum	A'cidi Nitrohydrochlo'rici	Nitrohydrochloric Acid
A'cidum Nitrohydrochlo'ricum Dilu'tum	A'cidi Nitrohydrochlo'rici Dilu'ti	Diluted Nitrohydrochloric Acid
A'cidum Ole'icum	A'cidi Ole'ici	Oleic Acid
A'cidum Phospho'ricum	A'cidi Phospho'rici	Phosphoric Acid
A'cidum Phospho'ricum Dilu'tum	A'cidi Phospho'rici Dilu'ti	Diluted Phosphoric Acid

A'cidum Salicy'licum	A'cidi Salicy'lici	Salicylic Acid
A'cidum Stea'ricum	A'cidi Stea'rici	Stearic Acid
A'cidum Sulphu'ricum	A'cidi Sulphu'rici	Sulphuric Acid
A'cidum Sulphu'ricum Dilu'tum	A'cidi Sulphu'rici Dilu'ti	Diluted Sulphuric Acid
A'cidum Sulphu'ricum Aroma'ticum	A'cidi Sulphu'rici Aroma'tici	Aromatic Sulphuric Acid
A'cidum Sulphuro'sum	A'cidi Sulphuro'si	Sulphurous Acid
A'cidum Tan'nicum	A'cidi Tan'nici	Tannic Acid
A'cidum Tarta'ricum	A'cidi Tarta'rici	Tartaric Acid

Several of the foregoing titles are not chemically correct as the substances named are not in reality acids although commonly called such. Thus "arsenous acid" is an oxide or anyhydride, carbolic acid is an alcohol, "chromic acid" is an anhydride, "nitrohydrochloric acid" is a mixture of several substances, and "aromatic sulphuric acid" is a still more complex mixture.

The student should observe that the titles of the acids all contain one or two adjectives governed by the substantive noun *acidum* both as to gender and case. One of the adjectives indicates the *kind* of acid chemically, while the other indicates the relative purity or strength, etc.

Further reference to the latinic adjectives commonly employed in pharmaceutical nomenclature will be found in paragraphs 1591 and 1597.

1591. In this paragraph are grouped the common latinic titles of chemicals not included in the preceding paragraphs. [A sufficient number of solutions and certain other *preparation*s of chemicals having generic titles formed in the same manner as those applied to galenical preparations will be named in paragraph 1596.]

Argen'ti Ni'tras Dilu'tus	Argen'ti Nitra'tis Dilu'ti	Diluted Silver Nitrate
Argen'ti Ni'tras Fu'sus	Argen'ti Nitra'tis Fu'si	Fused Silver Nitrate
Cal'cii Carbo'nas Præcipita'tus	Cal'cii Carbona'tis Præcipita'ti	Precipated Calcium Carbonate
Cal'cii Phos'phas Præcipita'tus	Cal'cii Phospha'tis Præcipitati	Precipitated Calcium Phosphate
Fer'ri Sul'phas Præcipita'tus	Fer'ri Sulpha'tis Præcipita'ti	Precipitated Iron Sulphatr
Zin'ci Carbo'nas Præcipita'tus	Zin'ci Carbona'tıs Præcipita'ti	Precipitated Zinc Carbon'
Cal'cii Sul'phas Exsicca'tus	Cal'cii Sulpha'tis Exsicca'ti	Dried Calcium Sulphate
Fer'ri Sul'phas Exsicca'tus	Fer'ri Sulpha'tis Exsicca'ti	Dried Iron Sulphate

So'dii Carbo'nas Exsicca'tus	So'dii Carbona'tis Exsicca'ti	Dried Sodium Carbonate
Fer'ri Carbo'nas Sacchara'tus	Fer'ri Carbona'tis Sacchara'ti	Saccharated Iron Carbonate
Fer'ri Sul'phas Granula'tus	Fer'ri Sulpha'tis Granula'ti	Granulated Iron Sulphate
Ae'ther Ace'ticus	Ae'theris Ace'tici	Acetic Ether
Ae'ther Nitro'sus	Ae'theris Nitro'si	Nitrous Ether
Hydrar'gyri Subsul'phas Fla'vus	Hydrar'gyri Subsulpha'tis Fla'vi	Yellow Mercury Subsulphate
Fer'ri et Quini'næ Ci'tras Solu'bilis	Fer'ri et Quini'næ Citra'tis Solu'bilis	Soluble Iron-Quinine Citrate
Fer'ri Phos'phas Solu'bilis	Fer'ri Phospha'tis Solu'bilis	Soluble Iron Phosphate
Fer'ri Pyrophos'phas Solu'bilis	Fer'ri Pyrophospha'tis Solu'bilis	Soluble Iron Pyrophosphate
Li'thii Ci'tras Efferves'cens	Li'thii Citrat'is Effervescen'tis	Effervescent Lithium Citrate
Magne'sii Ci'tras Effervescens	Magne'sii Citra'tis Effervescentis	Effervescent Magnesium Citrate
Calx Chlora'ta	Cal'cis Chlora'tæ	Chlorinated Lime
Calx Sulphura'ta	Cal'cis Sulphura'tæ	Sulphurated Lime
So'da Chlora'ta	So'dæ Chlora'tæ	Chlorinated Soda
Magne'sia Le'vis	Magne'siæ Le'vis	Light Magnesia
Magne'sia Pondero'sa	Magne'siæ Pondero'sæ	Heavy Magnesia
Potas'sa Sulphura'ta	Potas'sæ Sulphura'tæ	Sulphurated Potassa
Cam'phora Monobroma'ta	Cam'phoræ Monobroma'tæ	Monobromated Camphor
Antimo'num Sulphura'tum	Antimo'ni Sulphura'ti	Sulphurated Antimony
Fer'rum Reduc'tum	Fer'ri Reduc'ti	Reduced Iron
Hydrar'gyrum Ammonia'tum	Hydrar'gyri Ammonia'ti	Ammoniated Mercury
Alu'men Exsicca'tum	Alu'minis Exsicca'ti	Dried Alum
Antimo'ni Sulphi'dum Purifica'tum	Antimo'ni Sulphi'di Purifica'ti	Purified Antimony Sulphide
Fer'ri Io'didum Sacchara'tum	Fer'ri Io'didi Sacchara'ti	Saccharated Iron Iodide
Fer'ri Ox'idum Hydra'tum	Fer'ri Ox'idi Hydra'ti	Hydrated Iron Oxide
Fer'ri Ox'idum Hydra'tum cum Magnesia	Fer'ri Oxi'di Hydra'ti cum Magnesia	Hydrated Iron Oxide with Magnesia
Hydrar'gyri Chlo'ridum Corrosi'vum	Hydrar'gyri Chlo'ridi Corrosi'vi	Corrosive Mercury Chloride
Hydrar'gyri Chlo'ridum Mi'te	Hydrar'gyri Chlo'ridi Mi'tis	Mild Mercury Chloride
Hydrar'gyri Io'didum Fla'vum	Hydrar'gyri Io'didi Fla'vi	Yellow Mercury Iodide
Hydrar'gyri Io'didum Ru'brum	Hydrar'gyri Io'didi Ru'bri	Red Mercury Iodide
Hydrar'gyri Io'didum Vi'ride	Hydrar'gyri Io'didi Vi'ridis	Green Mercury Iodide
Hydrar'gyri Ox'idum Fla'vum	Hydrar'gyri Ox'idi Fla'vi	Yellow Mercury Oxide
Hydrar'gyri Ox'idum Ru'brum	Hydrar'gyri Ox'idi Ru'bri	Red Mercury Oxide
Sul'phur Lo'tum	Sul'phuris Lo'ti	Washed Sulphur
Sul'phur Præcipita'tum	Sul'phuris Præcipita'ti	Precipitated Sulphur
Sul'phur Sublima'tum	Sul'phuris Sublima'ti	Sublimed Sulphur
Al'cohol Absolu'tum	Al'cohol Absolu'ti	Absolute Alcohol
Al'cohol Deodora'tum	Al'cohol Deodora'ti	Deodorized Alcohol
Al'cohol Dilu'tum	Al'cohol Dilu'ti	Diluted Alcohol
O'leum Æthe'reum	O'lei Æthe'rei	Æthereal Oil
Glycyrrhizi'num Ammonia'tum	Glycyrrhizi'ni Ammonia'ti	Ammoniated Glycyrrhizin

1592. The Latinic titles of crude organic drugs are usually identical with the present technical English titles. The names of vegetable drugs are generally the genus names of plants, but sometimes species names or other words are employed We shall here group them according to their declensions, and shall include the animal drugs with the plant drugs:—

Latinic Titles Following the First Declension.

Latinic Titles.		English Technical	English Common
Nominative.	*Genitive.*	*Titles.*	*Names.*
Aca´cia	Aca´ciæ	Acacia	Gum Arabic
Althæ´a	Althæ´æ	Althæa	Marshmallow
Amyg´dala	Amyg´dalæ		Almond
Arni´ca	Arni´cæ	Arnica	Arnica
Asafœ´tida	Asafœ´tidæ	Asafetida	Asafetida
Belladon´na	Belladon´næ	Belladonna	Deadly Night-Shade
Bryo´nia	Bryo´niæ	Bryonia	
Calen´dula	Calen´dulæ	Calendula	
Calum´bo	Calum´bæ	Calumba	Columbo
Cambo´gia	Cambo´giæ		Gamboge
Cam´phora	Cam´phoræ		Camphor
Cascaril´la	Cascaril´læ	Cascarilla	Cascarilla
Cas´sia	Cas´siæ	Cassia	
Casta´nea	Casta´neæ	Castanea	Chestnut Leaves
Ce´ra	Ce´ræ		Wax
Cetra´ria	Cetra´riæ	Cetraria	Iceland Moss
Chima´phila	Chima´philæ	Chimaphila	Pipsissewa
Chira´ta	Chira´tæ	Chiretta	
Cimici´fuga	Cimici´fugæ	Cimicifuga	Black Cohosh
Cincho´na	Cincho´næ	Cinchona	Cinchona
Convalla´ria	Convalla´riæ	Convallaria	Lily-of-the-Valley
Copai´ba	Copai´bæ	Copaiba	Copaiba
Cube´ba	Cube´bæ	Cubeb	Cubeb
Dulcama´ra	Dulcama´ræ	Dulcamara	Bittersweet
Elas´tica	Elas´ticæ		Caoutchuc
Er´gota	Er´gotæ	Ergot	Ergot
Fran´gula	Fran´gulæ	Frangula	Buckthorn Bark
Gal´la	Gal´læ		Nutgall
Gaulthe´ria	Gaulthe´riæ	Gaultheria	Wintergreen
Gentia´na	Gentia´næ		Gentian
Glycyrrhi´za	Glycyrrhi´zæ	Glycyrrhiza	Licorice Root
Grinde´lia	Grinde´liæ	Grindelia	
Guara´na	Guara´næ	Guarana	
Hedeo´ma	Hedeo´mæ	Hedeoma	Pennyroyal
Ichtyocol´la	Ichtyocol´læ		Isinglass Fish-glue
I´nula	I´nulæ	Inula	Elecampane
Ipecacuan´ha	Ipecacuan´hæ		Ipecac

Jala'pa	Jala'pæ		Jalap
Krame'ria	Krame'riæ	Krameria	Rhatany
Lap'pa	Lap'pæ	Lappa	Burdock
Lavan'dula	Lavan'dulæ		Lavender
Leptan'dra	Leptan'dræ	Leptandra	Culver's Root
Lobe'lia	Lobe'liæ	Lobelia	Lobelia
Man'na	Man'næ	Manna	Manna
Matrica'ria	Matrica'riæ	Matricaria	German Chamomile
Melis'sa	Melis'sæ	Melissa	Balm
Men'tha	Men'thæ		Mint
Myris'tica	Myris'ticæ		Nutmeg
Myr'rha	Myr'rhæ		Myrrh
Pare'ira	Pare'iræ	Pareira	Pareira
Phytolac'ca	Phytolac'cæ	Phytolacca	Poke
Pimen'ta	Pimen'tæ	Pimenta	Allspice
Pulsatil'la	Pulsatil'læ	Pulsatilla	Pulsatilla
Quas'sia	Quas'siæ	Quassia	Quassia
Quilla'ja	Quilla'jæ	Quillaya	Soap Bark
Resi'na	Resi'næ		Resin
Ro'sa	Ro'sæ		Rose
Sabi'na	Sabi'næ		Savin
Sal'via	Sal'viæ	Salvia	Sage
Sanguina'ria	Sanguina'riæ	Sanguinaria	Bloodroot
Santo'nica	Santo'nicæ	Santonica	Levantic Wormseed
Sarsaparil'la	Sarsaparil'læ	Sarsaprilla	Sarsaparilla
Scil'la	Scil'læ		Squill
Scutella'ria	Scutella'riæ	Scutellaria	Scullcap
Se'nega	Se'negæ	Senega	Seneca Snakeroot
Sen'na	Sen'næ	Senna	Senna
Serpenta'ria	Serpenta'riæ	Serpentaria	Virginia Snakeroot
Spige'lia	Spige'liæ	Spigelia	Pinkroot
Staphisa'gria	Staphisa'griæ	Staphisagria	Stavesacre
Stillin'gia	Stillin'giæ	Stillingia	Queen's Root
Tragacan'tha	Tragacan'thæ		Tragacanth
Valeria'na	Valeria'næ	Valerian	Valerian
Vanil'la	Vanil'læ	Vanilla	Vanilla
A'loe	A'loes		Aloes
Mas'tiche	Mas'tiches		Mastic

Latinic Titles Following the Second Declension.

[Alnus, Juniperus, sambucus and ulmus are feminine; other titles masculine if ending in —*us*, neuter if ending in —*um*.]

Latinic Titles.		*English Technical*	*English Common*
Nominative.	*Genitive.*	*Titles.*	*Names.*
Al'nus, f	Al'ni	Alnus	Alder
Cal'amus	Cal'ami	Calamus	Sweet Flag
Caryophyl'lus	Caryophyl'li		Cloves
Chon'drus	Chon'dri	Chondrus	Irish Moss

Coc'cus	Coc'ci		Cochineal
Cro'cus	Cro'ci		Saffron
Eucalyp'tus	Eucalyp'ti	Eucalyptus	Eucalyptus
Euo'nymus	Euo'nymi	Euonymus	Wahoo Bark
Hu'mulus	Hu'muli		Hops
Hyoscy'amus	Hyoscy'ami	Hyoscyamus	Henbane
Juni'perus, f	Jun'iperi		Juniper
Mos'chus	Mos'chi		Musk
Pilocar'pus	Pilocar'pi	Pilocarpus	Jaborandi
Rosmari'nus	Rosmari'ni		Rosemary
Ru'bus	Ru'bi	Rubus	
Sambu'cus, f	Sambu'ci		Elder Flowers
Scopa'rius	Scopar'ii	Scoparius	Broom
Strophan'thus	Strophan'thi	Strophanthus	Strophanthus
Tamarin'dus	Tamarin'di		Tamarind
Thy'mus	Thy'mi		Thyme
Ul'mus; f	Ul'mi	Ulmus	Slippery Elm
Vitel'lus	Vitel'li		Yolk of Egg
Absin'thium	Absin'thii	Absinthium	Wormwood
Aconi'tum	Aconi'ti		Aconite
Al'lium	Al'lii	Allium	Garlic
A'mylum	A'myli		Starch
Ammoni'acum	Ammoni'aci		Ammoniae
Ani'sum	Ani'si		Anise
Apo'cynum	Apo'cyni	Apocynum	Black Indian Hemp
Aspi'dium	Aspi'dii	Aspidium	Male Fern
Auran'tium	Auran'tii		Orange
Cap'sicum	Cap'sici	Capsicum	Red Pepper
Benzoi'num	Benzoi'ni		Benzoin
Cardamo'mum	Cardamo'mi		Cardamom
Car'um	Ca'ri		Caraway
Ceta'ceum	Ceta'cei	Cetaceum	Spermaceti
Caulophyl'lum	Caulophyl'li	Caulophyllum	Blue Cohosh
Chelido'nium	Chelido'nii	Chelidonium	Celandine
Chenopo'dium	Chenopo'dii	Chenopodium	American Wormseed
Cinnamo'mum	Cinnamo'mi		Cinnamon
Col'chicum	Col'chici	Colchicum	Colchicum
Coni'um	Coni'i	Conium	Poison Hemlock
Corian'drum	Corian'dri		Coriander
Creoso'tum	Creoso'ti		Creosote
Cypripe'dium	Cypripe'dii	Cypripedium	Lady's Slipper
Eupato'rium	Eupato'rii	Eupatorium	Boneset
Foeni'culum	Foeni'culi		Fennel
Gelse'mium	Gelse'mii	Gelsemium	Yellow Jasmine
Gera'nium	Gera'nii	Geranium	Cranesbill
Gossy'pium	Gossy'pii	Gossypium	Cotton-root Bark
Grana'tum	Grana'ti	Granatum	Pomegranate
Guaia'cum	Guaia'ci		Guaiac
Illi'cium	Illi'cii		Star Anise
Lactuca'rium	Lactuca'rii	Lactucarium	Lactucarium

Li'num	Li'ni		Flaxseed
Lupuli'num	Lupuli'ni	Lupulin	Lupulin
Lycopo'dium	Lycopo'dii	Lycopodium	Lycopodium
Marru'bium	Marru'bii	Marrublum	Hoarhound
Menisper'mum	Menisper'mi	Menispermum	Yellow Parilla
Meze'reum	Meze'rei	Mezereum	Mezereon
O'leum	O'lei		Oil
O'pium	O'pii	Opium	Opium
Petrola'tum	Petrola'ti	Petrolatum	Petrolatum
Podophyl'lum	Podophyl'li	Podophyllum	Mandrake
Pru'num	Pru'ni		Prune
Pyre'thrum	Pyre'thri	Pyrethum	Pellitory
Rhe'um	Rhe'i		Rhubarb
Sac'charum	Sac'chari		Sugar
San'talum	San'tali	Santalum	
Se'vum	Se'vi		Suet
Stramo'nium	Stramo'nii	Stramonium	Thornapple
Taba'cum	Taba'ci		Tobacco
Tanace'tum	Tanace'ti		Tansy
Tara'xacum	Tara'xaci	Taraxacum	Dandelion
Tri'ticum	Tri'tici	Triticum	Couch-Grass
Vera'trum	Vera'tri	Veratrum	
Vibu'rnum	Vibu'rmi	Viburnum	
Xanthox'ylum	Xanthox'yli	Xanthoxylum	Prickly-Ash
—	—	—	—
Diospy'ros	Diospy'ri	Diospyros	Persimmon
Pri'nos	Pri'ni	Prinus	Black Alder
—	—	—	—
Eriodic'tyon	Eriodic'tyi	Eriodictyon	Yerba Santa
Erythrox'ylon	Erythrox'yli	Erythroxylon	Coca
Hæmatox'ylon	Hæmatox'yli	Hæmatoxylon	Logwood

Latinic Titles Following the Third Declension

[Genders are indicated by m. for masculine, f. for feminine, and n. for neuter]

Latinic Titles.		English Technical	English Common
Nominative.	*Genitive.*	*Titles.*	*Names.*
Can'nabis; f	Can'nabis	Cannabis	Hemp
Digita'lis; f	Digita'lis	Digitalis	Fox-glove
Hydra'stis; f	Hydra'stis	Hydrastis	Golden Seal
Sina'pis; f	Sina'pis		Mustard
Fel; n	Fel'lis		Gall
Mel; n	Mel'lis		Honey
Li'mon; f	Limo'nis		Lemon
Pi'per; n	Pi'peris		Pepper
Zin'giber; n	Zingi'beris		Ginger
Pix; f	Pi'cis		
Ru'mex; m	Ru'micis	Rumex	Dock

Sty'rax; f	Sty'racis		Storax
A'deps; m	A'dipis		Lard
Lac; n	Lac'tis		Milk
Car'bo; m	Carbo'nis		Charcoal
Pe'po; m	Pepo'nis		Pumpkin Seed
Sa'po; m	Sapo'nis		Soap
Anthe'mis; f	Anthe'midis	Anthemis	Roman Chamomile
Ber'beris; f	Berbe'ridis	Berberis	Barberry
Can'tharɪs; f	Cantha'ridis	Cantharides	Spanish Flies
Colocyn'this; f	Colocyn'thidis	Colocynth	Colocynth
Hamame'lis; f	Hamame'lidis	Hamamelis	Witch Hazel
I'ris; f	I'ridis	Iris Versicolor	Blue Flag
Ma'cis; f	Ma'cidis		Mace
Ascle'pias; f	Asclepi'adis	Asclepias	Pleurisy Root
Ju'glans; f	Juglan'dis	Juglans	Butternut Bark
Eri'geron; n	Erigeron'tis	Erigeron	Fleabane
Rhus; f	Rho'is		
Aspidosper'ma	Aspidosper'matis	Aspidosperma	Quebraccho
Physostig'ma; f	Physostig'matis	Physostigma	Calabar-bean
Theobro'ma; f	Theobro'matis	Theobroma	Cacao

[The last three titles ending in—*ma* are of Greek origin, and do not follow the first declension.]

Latinic Titles Following the Fourth Declension.

Latinic Titles		*English Technial*	*English Common*
Nominative	*Genitive*	*Titles*	*Names*
Cor'nus; f	Cor'nus	Cornus	Dogwood Bark
Fi'cus; f	Fi'cus		Fig
Quer'cus; f	Quer'cus		Oak Bark

Latinic Titles of more than One Word.

Latinic Titles		*English Technical*	*English Common*
Nominative	*Genitive*	*Titles*	*Names*
Absin'thii Summita'tes	Absin'thii Summita'tum		Wormwood Tops
Aconi'ti Fo'lia	Aconi'ti Folio'rum		Aconite Leaves
Aconi'ti Ra'dix	Aconi'ti Radi'cis		Aconite Root
A'deps La'næ Hydro'sus	A'dipis La'næ Hyero'si		Hydrous Wool Fat
A'loe Barbaden'sis	A'loes Barbaden'sis		Barbadoes Aloes
A'loe Capen'sis	A'loes Capen'sis		Cape Aloes
A'loe Purifica'ta	A'loes Purifica'tæ		Purified Aloes
A'loe Socotri'na	A'loes Socotri'næ		Socotrine Aloes
Amyg'dala Ama'ra	Amyg'dalæ Ama'ræ		Bitter Almond
Amyg'dala Dul'cis	Amyg'dalæ Dul'cis		Sweet Almond
Amyg'dalæ Fari'na	Amyg'dalæ Fari'næ		Almond Meal
Arni'cæ Flo'res	Arni'cæ Flo'rum		Arnica Flowers

Arni'cæ Ra'dix	Arni'ca Radi'cis		Arnica Root
Auran'tii Ama'ri Cor'tex	Auran'tii Ama'ri Cor'ticis		Bitter Orange Peel
Aurant'ii Dul'cis Cor'tex	Auran'tii Dul'cis Cor'ticis		Sweet Orange Peel
Auran'tii Flo'res	Auran'tii Flo'rum		Orange Flowers
Belladon'næ Fo'lia	Belladon'næ Folio'rum		Belladonna Leaves
Belladon'næ Ra'dix	Belladon'næ Radi'cis		Belladonna Root
Can'nabis In'dica	Can'nabis In'dicæ	Cannabis Indica	Indian Hemp
Car'bo Anima'lis Purifica'tus	Carbo'nis Anima'lis Purifica'ti		Purified Animal Charcoal
Car'bo Lig'ni	Carbo'nis Lig'ni		Wood Charcoal
Ca'ri Fruc'tus	Ca'ri Fruc'tus		Caraway Fruit
Caryophyl'li Flo'res	Caryophyl'li Flo'rum		Cloves
Cas'sia Fis'tula	Cas'siæ Fis'tulæ	Cassia Fistula	
Ce'ra Al'ba	Ce'ræ Al'bæ		White Wax
Ce'ra Fla'va	Ce'ræ Fla'væ		Yellow Wax
Cincho'na Fla'va	Cincho'næ Fla'væ		Yellow Cinchona
Cincho'na Ru'bra	Cincho'næ Ru'bræ		Red Cinchona
Cinnamomo'mum Cas'sia	Cinnamo'mı Cas'siæ		Cassia Cinnamon
Cinnamomo'mum Saigo'nicum	Cinnamo'mi Saigo'nici		Saigon Cinnamon
Cinnamomo'mum Zeyla'nicum	Cinnamo'mi Zeyla'nici		Ceylon Cinnamon
Col'chici Cor'mus	Col'chici Cor'mi		Colchicum Root
Col'chici Ra'dix	Col'chici Radi'cis		Colchicum Root
Col'chici Se'men	Col'chici Se'minis		Colchicum Seed
Colocyn'thidis Pul'pa	Coiocyn'thidis Pul'pæ		Colocynth Pulp
Coni'i Fruc'tus	Coni'i Fruc'tus	Conium	Conium Fruit
Coni'i Her'ba	Coni'i Her'bæ		Conium Herb
Cro'ci Stig'mata	Cro'ci Stig'matum		Saffron
Dulcama'ræ Sti'pites	Dulcama'ræ Sti'pitum	Dulcamara	
Fel Bo'vis	Fel'lis Bo'vis		Ox-gall
Gossy'pii Lanu'go	Gossy'pii Lanu'ginis		Cotton
Gossy'pii Radi'cis Cor'tex	Gossy'pii Radi'cis Cor'ticis		Cotton-root Bark
Gossy'pium Purifica'tum	Gossy'pii Purifica'ti		Purified Cotton
Guaia'ci Lig'num	Guaia'ci Lig'ni		Guaiac Wood
Guaia'ci Resi'na	Guaia'ci Resi'næ		Guaiac Resin
Lavan'dulæ Flo'res	Lavan'dulæ Flo'rum		Lavender Flowers
Limo'nis Cor'tex	Limo'nis Cor'ticis		Lemon Peel
Limo'nis Suc'cus	Limonis Suc'ci		Lemon Juice
Men'tha Piperi'ta	Men'thæ Piperi'tæ		Peppermint
Men'tha Vi'ridis	Men'thæ Vi'ridis		Spearmint
Nux Vo'mica	Nu'cis Vo'micæ	Nux Vomica	
Petrola'tum Li'quidum	Petrola'ti Li'quidi		Liquid Petrolatum
Petrola'tum Mol'le	Petrola'ti Mol'lis		Soft Petrolatum
Petrola'tum Spis'sum	Petrola'ti Spis'si		Hard Petrolatum
Phytolac'cæ Fruc'tus	Phytolac'cæ Fruc'tus		Poke Berries

Phytolac'cæ Ra'dix	Phytolac'cæ Radi'cis		Poke Root
Pix Burgun'dica	Pi'cis Burgun'dicæ		Burgundy Pitch
Pix Li'quida	Pi'cis Li'quidæ		Tar
Pix So'lida	Pi'cis So'lidæ		Pitch
Pru'nus Virginia'na	Pru'ni Virginia'næ		Wild Cherry
Quer'cus Al'ba	Quer'cus Al'bæ		Oak Bark
Resi'na Copai'bæ	Resi'næ Copai'bæ		Copaiba Resin
Rham'nus Purshia'na	Rham'ni Purshia'næ		Cascara Sa'grada
Rhus Gla'bra	Rho'is Gla'bræ	Rhus Glabra	Sumach Berries
Rhus Toxicoden'dron	Rho'is Toxicoden'dri	Toxicodendron	Poison Ivy
Ro'sa Centifo'lia	Ro'sæ Centifo'liæ		Pale Rose
Ro'sa Gal'lica	Ro'sæ Gal'licæ		Red Rose
Ru'bus Idæ'us	Ru'bi Idæ'i		Raspberry
Sabi'næ Ra'muli	Sabi'næ Ramulo'rum		Savin
Sac'charum Lac'tis	Sac'chari Lac'tis		Milk Sugar
Sanguina'riæ Rhizo'ma	Sanguina'riæ Rhizo'matis		Blood Root
San'talum Ru'brum	San'tali Ru'bri		Red Saunders
Sa'po Du'rus	Sapo'nis Du'ri		Hard Soap
Sa'po Mol'lis	Sapo'nis Mol'lis		Soft Soap
Sas'safras Medul'la	Sas'safras Medul'læ		Sassafras Pith
Scopa'rii Cacu'mina	Scopa'rii Cacumino'rum		Broom Tops
Sina'pis Al'ba	Sina'pis Al'bæ		White Mustard
Sina'pis Ni'gra	Sina'pis Ni'græ		Black Mustard
Spi'ritus Frumen'ti	Spi'ritus Frumen'ti		Whiskey
Spi'ritus Vi'ni Gal'lici	Spi'ritus Vi'ni Gal'lici		Brandy
Stramo'nii Fo'lia	Stramo'nii Folio'rum		Stramonium Leaf
Stramo'nii Se'men	Stramo'nii Se'minum		Stramonium Seed
Terebin'thina America'na	Terebin'thinæ America'næ		American Turpentine
Terebin'thina Canaden'sis	Terebin'thinæ Canaden'sis		Canada Turpentine
Terebin'thina Vene'ta	Terebin'thinæ Vene'tæ		Venice Turpentine
U'va Ur'si	U'væ Ur'si	Uva Ursi	
Vera'trum Vi'ride	Vera'tri Vi'ridis	Veratrum Viride	American Hellebore
Vibur'num O'pulus	Vibur'ni O'puli	Viburnum Opulus	
Vibur'num Prunifo'lium	Vibur'ni Prunifo'lii	Viburnum Prunifolium	
Vi'num Al'bum	Vi'ni Al'bi		White Wine
Vi'num Porten'se	Vi'ni Porten'sis		Port Wine
Vi'num Ru'brum	Vi'ni Ru'bri		Red Wine
Vi'num Xe'ricum	Vi'ni Xe'rici		Sherry Wine

Indeclinable Latinic Titles of Organic Drugs.

Latinic Titles.		
Nominative and Genitive.	*Technical English Titles.*	*English Common Names.*
Aze'darach	Aze'darach	
Bu'chu	Bu'chu	
Ca'juput	Ca'juput	
Cate'chu	Cate'chu	
Co'ca	Co'ca	
Cura're	Cura're	
Cus'so	Cus'so	Kousso
Dia'chylon		Diachylon
E'lemi	E'lemi	
Elix'ir	Elix'ir	
Jaboran'di		Jaborandi
Kama'la	Kama'la	
Ki'no	Ki'no	
Ma'tico	Ma'tico	
Sa'go		Sago
Sas'safras	Sas'safras	
Sum'bul	Sum'bul	

The words "cajuput" and "coca" are *not* treated as indeclinable in the Pharmacopœia of the United States.

1593. Latinic Names of Plant Parts and of certain structureless Crude Drugs of Vegetable Origin.

[Genders are indicated by m. for masculine, f. for feminine, and n. for neuter.]

Latinic Titles.		
Nominative.	*Genitive.*	*English Names.*
Aril'lus; m	Aril'li	Arillus
Aril'li	Arillo'rum	Arilli
Bac'ca; f	Bac'cæ	Berry
Bac'cæ	Bacca'rum	Berries
Bul'bus; m	Bul'bi	Bulb
Bul'bi	Bulbo'rum	Bulbs
Cacu'men; n	Cacu'minis	Top
Cacu'mina	Cacu'minum	Tops Ends
Cor'tex; m	Cor'ticis	Bark
Flos; m	Flo'ris	Flower
Flo'res	Flo'rum	Flowers
Fo'lium; n	Fo'lii	Leaf
Fo'lia	Folio'rum	Leaves
Fruc'tus; m	Fruc'tus	Fruit
Fruc'tus	Fruc'tuum	Fruits
Glan'dulæ; f	Glandula'rum	Glands

Her'ba; f	Her'bæ	Herb
Lanu'go; f	Lanu'ginis	Fibre
Lig'num; n	Lig'ni	Wood
Medul'la; f	Medul'læ	Pith
Nux; f	Nu'cis	Nut
Nu'ces	Nu'cium	Nuts
Pe'tala; n	Petalo'rum	Petals
Pul'pa; f	Pul'pæ	Pulp
Ra'dix; f	Radi'cis	Root
Ra'muli; m	Ramulo'rum	Twigs
Rhizo'ma; f	Rhizo'matis	Rhizome
Se'men; n	Se'minis	Seed
Se'mina	Semi'num	Seeds
Spo'rulæ; f	Sporula'rum	Sporules
Stig'ma; f	Stig'matis	Stigma
Stig'mata	Stig'matum	Stigmas
Stipites; f	Sti'pitum	Stipes
Suc'cus; m	Suc'ci	Juice
Summitas; f	Summita'tis	Top
Summita'tes	Summita'tum	Tops
Tu'ber; n	Tu'beris	Tuber
Tu'bera	Tu'berum	Tubers

A'mylum; n	A'myli	Starch
Bal'samum; n	Bal'sami	Balsam
Fœ'cula; f	Fœ'culæ	Fecula
Gum'mi; n	Gum'mi	Gum
Gummi-Resi'na: f	Gummi-Resi'næ	Gum-resin
Oleo-Resi'na; f	Oleoresi'næ	Oleoresin
O'leum; n	O'lei	Oil
O'leum Expres'sum	O'lei Expres'si	Expressed Oil, Fixed Oil
O'leum Vola'tile	O'lei Vola'tilis	Volatile Oil
Pix; f	Pi'cis	Tar
Pyro'leum; n	Pyro'lei	
Resi'na; n	Resi'næ	Resin
Sac'charum; n	Sac'chari	Sugar

1594.　Latinic Titles of Oils, etc.

Latinic Titles.

Nominative.	Genitive.	English Names.
O'leum A'dipis,	O'lei A'dipis	Lard Oil
O'leum Aethe'reum	O'lei Aethe'rei	Ethereal Oil
O'leum Amyg'dalæ Ama'ræ	O'lei Amyg'dalæ Ama'ræ	Bitter Almond Oil
O'leum Amyg'dalæ Expres'sum	O'lei Amyg'dalæ Expres'si	Expressed Almond Oil
O'leum Ani'si	O'lei Ani'si	Anise Oil
O'leum Auran'tii Cor'ticis	O'lei Auran'tii Cor'ticis	Orange Peel Oil
O'leum Auran'tii Flo'rum	O'lei Auran'tii Flo'rum	Orange Flower Oil
O'leum Bergamot'tæ	O'lei Bergamot'tæ	Bergamot Oil
O'leum Be'tulæ Vola'tile	O'lei Be'tulæ Vola'tilis	Volatile Oil of Birch

O'leum Cadi'num	O'lei Cadi'ni	Oil of Cade
O'leum Ca'juput	O'lei Ca'juput	Cajuput Oil
O'leum Ca'ri	O'lei Ca'ri	Caraway Oil
O'leum Caryophyl'li	O'lei Caryophyl'li	Oil of Cloves
O'leum Chenopo'dii	O'lei Chenopo'dii	Oil of Chenopodium
O'leum Cinnamo'mi	O'lei Cinnamo'mi	Oil of Cinnamon
O'leum Copai'bæ	O'lei Copai'bæ	Oil of Copaiba
O'leum Corian'dri	O'lei Corian'dri	Coriander Oil
O'leum Cube'bæ	O'lei Cube'bæ	Cubeb Oil
O'leum Erigeron'tis	O'lei Erigeron'tis	Oil of Erigeron
O'leum Eucalyp'ti	O'lei Eucalyp'ti	Oil of Eucalyptus
O'leum Foeni'culi	O'lei Foeni'culi	Fennel Oil
O'leum Gaulthe'riæ	O'lei Gaulthe'riæ	Oil of Wintergreen
O'leum Gossy'pii Se'minum	O'lei Gossy'pii Se'minum	Cotton Seed Oil
O'leum Hedeo'mæ	O'lei Hedeo'mæ	Oil of Pennyroyal
O'leum Juni'peri	O'lei Juni'peri	Juniper Oil
O leum Lavan'dulæ Flo'rum	O'lei Lavan'dulæ Flo'rum	Oil of Lavender Flowers
O'leum Limo'nis	O'lei Limo'nis	Lemon Oil
O leum Li'ni	O'lei Li'ni	Flaxseed Oil
O'leum Men'thæ Piperi'tæ	O'lei Men'thæ Piperi'tæ	Peppermint Oil
O'leum Men'thæ Vi'ridis	O'lei Men'thæ Vi'ridis	Spearmint Oil
O'leum Mor'rhuæ	O'lei Mor'rhuæ	Cod Liver Oil
O'leum Myr'ciæ	O'lei Myr'ciæ	Bayberry Oil
O'leum Myris'ticæ Expres'sum	O'lei Myris'ticæ Expres'si	Nutmeg Butter
O'leum Myris'ticæ Vola'tile	O'lei Myris'ticæ Vola'tilis	Volatile Oil of Nutmeg
O'leum Oli'væ	O'lei Oli'væ	Olive Oil
O'leum Pi'cis Li'quidæ	O'lei Pi'cis Li'quidæ	Oil of Tar
O'leum Pimen'tæ	O'lei Pimen'tæ	Pimenta Oil
O'leum Ri'cini	O'lei Ri'cini	Castor Oil
O'leum Ro'sæ	O'lei Ro'sæ	Rose Oil
O'leum Rosmari'ni	O'lei Rosmari'ni	Rosemary Oil
O'leum Sabi'næ	O'lei Sabi'næ	Savin Oil
O'leum San'tali	O'lei San'tali	Santal Oil
O'leum Sas'safras	O'lei Sas'safras	Sassafras Oil
O'leum Se'sami	O'lei Se'sami	Sesame Oil
O'leum Sina'pis Expres'sum	O'lei Sina'pis Expres'si	Fixed Oil of Mustard
O'leum Sina'pis Vol'atile	O'lei Sina'pis Vola'tilis	Volatile Oil of Mustard
O'leun Terebin'thinæ	O'lei Terebin'thinæ	Oil of Turpentine
O'leum Terebin'thinæ Rectifica'tum	O'lei Terebin'thinæ Rectifica'ti	Rectified Oil of Turpentine
O'leum Theobro'matis	O'lei Theobro'matis	Cacao Butter
O'leum Thy'mi	O'lei Thy'mi	Thyme Oil
O'leum Tig'lii	O'lei Tig'lii	Croton Oil

1595 Latinic Generic Titles of Classes of Pharmaceutical Preparations. [Genders indicated by m. for masculine, f. for femine, and n. for neuter.]

Latinic Titles.

Nominative.	Genitive.	English Titles
Abstrac'tum; n	Abstra'cti	Abstract
Abstrac'ta	Abstracto'rum	Abstracts
Ace'tum; n	Ace'ti	Vinegar
Ace'ta	Aceto'rum	Vinegars
A'qua; f	A'quæ	Water
A'quæ	Aqua'rum	Waters
Bacil'lus; m	Bacil'li	Bacillus
Bacil'li	Bacillor'um	Bacilli
Bal'neum. n	Bal'nei	Bath
Bo'lus; m	Bo'li	Bolus
Bo'li	Bolo'rum	Boli
Bou'gium; n	Bou'gii	Bougie
Bou'gia	Bougio'rum	Bougies
Cap'sula; f	Cap'sulæ	Capsule
Cap'sulæ	Capsula'rum	Capsules
Car'basus; m	Car'basi	Gauze
Cataplas'ma; f	Cataplas'matis	Poultice
Cera'tum; n	Cera'ti	Cerate
Cera'ta	Cerato'rum	Cerates
Cere'olum; n	Cere'oli	Wax Bougie
Cere'oli	Cereolo'rum	Wax Bougies
Char'ta: f	Char'tæ	Paper
Colatu'ra; f	Colatu'ræ	Colature
Collo'dium; n	Collo'dii	Collodion
Colluna'rium; n	Colluna'rii	Nasal Douche
Colluto'rium; n	Colluto'rii	Mouth Wash
Colly'rium; n	Colly'rii	Eye Wash
Confec'tio; f	Confectio'nis	Confection
Confectio'nes	Confectio'num	Confections
Confec'tum; n	Confec'ti	Confection
Conser'va; f	Conser'væ	Conserve
Decoc'tio; f	Decoctio'nis	Decoction
Decoctio'nes	Decoctio'num	Decoctions
Decoc'tum; n	Decoc'ti	Decoction
Decoc'ta	Decocto'rum	Decoctions
Electua'rium; n	Electua'rii	Electuary
Electua'ria	Electuario'rum	Electuaries
Emplas'trum; n	Emplas'tri	Plaster
Emplas'tra	Emplastro'rum	Plasters
Emul'sio; f	Emulsio'nis	Emulsion
Emulsio'nes	Emulsio'num	Emulsions
Emul'sum; n	Emul'si	Emulsion
Emul'sa	Emulso'rum	Emulsions
E'nema; f	Ene'matis	Enema
Ene'mata	Ene'matum	Enemas
Extrac'tum; n	Extrac'ti	Extract
Extrac'ta	Extracto'rum	Extracts
Extrac'tum Flu'idum	Extrac'ti Flu'idi	Fluid Extract

Extrac'ta Flu'ida	Extracto'rum Fluido'rum	Fluid Extracts
Fari'na; f	Fari'næ	Flour Meal
Gargaris'ma; f	Gargaris'matis	Gargle
Gelati'na; f	Gelati'næ	Gelatin or Jelly
Gela'tum; n	Gela'ti	Gelatin or Jelly
Glyceri'tum: n	Glyceri'ti	Glycerite
Glyceri'ta	Glycerito'rum	Glycerites
Gra'nula; f	Gra'nulæ	Granule
Gra'nulæ	Granula'rum	Granules
Gut'ta; f	Gut'tæ	Drop
Gut'tæ	Gutta'rum	Drops
Haus'tus; m	Haus'tus	Draft
Infu'sio; f	Infusio'nis	Infusion
Infusio'nes	Infusio'num	Infusions
Infu'sum; n	Infu'si	Infusion
Infu'sa	Infuso'rum	Infusions
Injec'tio; f	Injectio'nis	Injection
Injectio'nes	Injectio'num	Injections
Injectum; n	Injec'ti	Injection
Injec'ta	Injecto'rum	Injections
Inhala'tio; f	Inhalatio'nis	Inhalation
Inhalatio'nes	Inhalatio'num	Inhalations
Inhala'tum; n	Inhala'ti	Inhalation
Inhala'ta	Inhalato'rum	Inhalations
Jula'pium; n	Jula'pii	Julep
Jula'pia	Julapio'rum	Juleps
Lamel'la; f	Lamel'læ	Lamella
Lamel'læ	Lamella'rum	Lamallæ
Linc'tus; m	Linc'ti	Linctus
Linimen'tum; n	Linimen'ti	Liniment
Linimen'ta	Linimento'rum	Liniments
Lo'tio; f	Lotio'nis	Lotion
Lotio'nes	Lotio'num	Lotions
Li'quor; m	Liquo'ris	Liquor ("Solution")
Liquo'res	Liquo'rum	Liquores
Macera'tum; n	Macera'ti	Macerate
Mas'sa; f	Mas'sæ	Mass
Mas'sæ	Massa'rum	Masses
Mel; n	Mel'lis	Honey
Melli'tum; n	Melli'ti	Honey
Melli'ta	Mellito'rum	Honeys
Mella'go; f	Mella'ginis	Mellago
Mella'gines	Mella'ginum	
Mistu'ra; f	Mistu'ræ	Mixture
Mistu'ræ	Mistura'rum	Mixtures
Mucila'go; f	Mucila'ginis	Mucilage
Mucila'gines	Mucila'ginum	Mucilages
Olea'tum; n	Olea'ti	Oleate
Olea'ta	Oleato'rum	Oleates
Oleoresi'na; f	Oleoresi'næ	Oleoresin
Oleoresi'næ	Oleoresina'rum	Oleoresins

Oleosac´charum; n	Oleosac´chari	Oilsugar
Oleosac´chara	Oleosaccharo´rum	Oilsugars
O´leum; n	O´lei	Oil
O´lea	Oleo´rum	Oils
Ox´ymel; n	Oxymel´lis	Oxymel
Oxymelli´tum; n	Oxymellito´rum	
Pas´ta; f	Past´æ	Pasta
Pastil´lus; m	Pastil´li	Pastil
Pastil´li	Pastillo´rum	Pastils
Percola´tum; n	Percola´ti	Percolate
Pessa´rium; n	Pessa´rii	Pessary
Pessa´ria	Pessario´rum	Pessaries
Pi´lula; f	Pi´lulæ	Pill
Pi´lulæ	Pilula´rum	Pills
Po´tio; f	Potio´nis	Potion
Potio´nes	Potio´num	Potions
Po´tus; m	Po´ti	Potion
Po´ti	Poto´rum	Potions
Pul´vis; m	Pul´veris	Powder
Pul´veres	Pul´verum	Powders
Resi´na; f	Resi´næ	Resin
Resi´næ	Resina´rum	Resins
Ro´ob; n	Ro´ob	Roob
Ro´tula; f	Ro´tulæ	Sugar-drop
Ro´tulæ	Rotula´rum	
Se´ricum ; n	Se´rici	Silk
Se´rica	Serico´rum	
Solu´tio; f	Solutio´r·is	Solution
Solutio´nes	Solutio´num	Solutions
Solu´tum; n	Solu´ti	Solution
Solu´ta	Soluto´rum	Solutions
Spe´cies; f	Specie´rum	Species. Tea
Spi´ritus; m	Spi´ritus	Spirit
Spi´ritus	Spi´ritum	Spirits
Suc´cus; m	Suc´ci	Juice
Suc´ci	Succo´rum	Juices
Supposito´rium; n	Supposito´rii	Suppository
Supposito´ria	Suppositorio´rum	Suppositories
Syru´pus; m	Syru´pi	Syrup
Syru´pi	Syrupo´rum	Syrups
Tabel´la; f	Tabel´læ	Tablet
Tabel´læ	Tabella´rum	Tablets
Tinctu´ra; f	Tinctu´ræ	Tincture
Tinctu´ræ	Tinctura´rum	Tinctures
Tinctu´ra Aethe´rea	Tinctu´ræ Aethe´reæ	Ethereal Tincture
Tinctu´ra Ammonia´ta	Tinctu´ræ Ammonia´tæ	Ammoniated Tincture
Tritura´tio; f	Trituratio´nis	Trituration
Trituratio´nes	Trituratio´num	Triturations
Tritura´tum; n	Tritura´ti	Trituration
Tritura´ta	Triturato´rum	Triturations
Trochis´cus; m	Trochis´ci	Troche

Trochis'ci	Trochisco'rum	Troches
Unguen'tum; n	Unguen'ti	Ointment
Unguen'ta	Unguento'rum	Ointments
Vi'num; n	Vi'ni	Wine
Vi'na	Vino'rum	Wines
Va'por; m	Vapo'ris	Vapor
Vapo'res	Vapo'rum	Vapors

1596 Latinic Specific Titles of Individual Galenical and Chemical Pharmaceutical Preparations are sufficiently illustrated in the following lists:—

Latinic Titles.

Nominative.	Genitive.	English Titles.
Ace'tum O'pii	Ace'ti O'pii	Opium Vinegar
Ace'tum Scil'læ	Ace'ti Scil'læ	Squill Vinegar
A'deps Benzoina'tus	A'dipis Benzoina'ti	Benzoinated Lard
Al'cohol Dilu'tum	Al'cohol Dilu'ti	Diluted Alcohol
A'loe Purifica'ta	A'loes Purifica'tæ	Purified Aloes
A'qua Ani'si	A'quæ Ani'si	Anise Water
A'qua Cam'phoræ	A'quæ Cam'phoræ	Camphor Water
A'qua Distilla'ta	A'quæ Destilla'tæ	Distilled Water
A'qua Hydroge'nii Diox'idi	A'quæ Hydroge'nii Diox'idi	Hydrogen Dioxide Solution
A'qua Ro'sæ	A'quæ Ro'sæ	Rose Water
A'qua Ro'sæ For'tior	A'qua Ro'sæ Fortio'ris	Stronger Rose Water
Cera'tum Cantha'ridis	Cera'ti Cantha'ridis	Cantharides Cerate
Cera'tum Plum'bi Subaceta'tis	Cera'ti Plum'bi Subaceta'tis	Cerate of Lead Subacetate
Char'ta Sina'pis	Char'tæ Sina'pis	Mustard Paper
Collo'dium Flex'ile	Collo'dii Flex'ilis	Flexible Collodion
Confec'tio Sen'næ	Confectio'nis Sen'næ	Senna Confection
Decoc'tum Cetra'riæ	Decoc'ti Cetra'riæ	Cetraria Decoction
Decoc'tum Sarsaparil'læ Compo'situm	Decoc'ti Sarsaparil'læ Compo'siti	Compound Sarsaparilla Decoction
Elix'ir Aroma'ticum	Elix'ir Aroma'tici	Aromatic Elixir
Elix'ir Phos'phori	Elix'ir Phos'phori	Phosphorus Elixir
Emplas'trum Ammoni'aci cum Hydrar'gyro	Emplas'tri Ammoni'aci cum Hydrar'gyro	Ammoniac Plaster with Mercury
Emplas'trum Plum'bi	Emplas'tri Plum'bi	Lead Plaster
Emplas'trum Resi'næ	Emplas'tri Resi'næ	Resin Plaster
Emul'sum Amyg'dalæ	Emul'si Amyg'dalæ	Almond Emulsion
Emul'sum Asafœ'tidæ	Emul'si Asafœ'tidæ	Asafetida Emulsion
Extrac'tum Aconi'ti	Extrac'ti Aconi'ti	Aconite Extract
Extrac'tum Aconi'ti Flu'idum	Extrac'ti Aconi'ti Flu'idi	Fluid Extract of Aconite
Extrac'tum Arni'cæ Radi'cis Flu'idum	Extrac'ti Arni'cæ Radi'cis	Extract of Arnica Root
Extrac'tum Aroma'ticum Flu'idum	Extrac'ti Aroma'tici Flu'idi	Aromatic Fluid Extract
Extrac'tum Belladon'næ Folio'rum Alcoho'licum	Extrac'ti Belladon'næ Folio'rum Alcoho'lici	Alcoholic Extract of Belladonna Leaves
Extrac'tum Er'gotæ	Extrac'ti Er'gotæ	Ergot Extract

Extrac'tum Er'gotæ Flu'idum	Extrac'ti Er'gotæ Flu'idi	Fluid Extract of Ergot
Extrac'tum Glycyrrhi'zæ Pu'rum	Extrac'ti Glycyrrhi'zæ Pu'ri	Pure Extract of Glycyrrhiza
Extrac'tum Nu'cis Vo'micæ	Extrac'ti Nu'cis Vo'micæ	Extract of Nux Vomica
Extrac'tum Sarsaparil'læ Flu'idum Compo'situm	Extrac'ti Sarsaparil'læ Flu'idi Compo'siti	Compound Fluid Extract of Sarsaparilla
Extrac'tum U'væ Ur'si	Extrac'ti U'væ Ur'si	Extract of Uva Ursi
Fel Bo'vis Purifica'tum	Fel'lis Bo'vis Purifica'ti	Purified Ox Gall
Glyceri'tum A'cidi Tan'nici	Glyceri'ti A'cidi Tan'nici	Glycerite of Tannic Acid
Glyceri'tum Hydras'tis	Glyceri'ti Hydras'tis	Glycerite of Hydrastis
Hydrar'gyrum cum Cre'ta	Hydrar'gyri cum Cre'ta	Mercury with Chalk
Infu'sum Digita'lis	Infu'si Digita'lis	Digitalis Infusion
Infu'sum Pru'ni Virginia'næ	Infu'si Pru'ni Virginia'næ	Infusion of Wild Cherry
Linimen'tum Belladon'næ	Linimen'ti Belladon'næ	Belladonna Liniment
Linimen'tum Cal'cis	Linimen'ti Cal'cis	Lime Liniment
Linimen'tum Sapo'nis Mol'lis	Linimen'ti Sapo'nis Mol'lis	Soft-Soap Liniment
Li'quor A'cidi Arseno'si	Liquo'ris A'cidi Arseno'si	Solution of Arsenous Acid
Li'quor Ammo'nii Aceta'tis	Liquo'ris Ammo'nii Aceta'tis	Solution of Ammonium Acetate
Li'quor Arse'ni et Hydrar'gyri Io'didi	Liquo'ris Arse'ni et Hydrar'gyri Io'didi	Solution of Iodide of Arsenic and Mercury
Li'quor Cal'cis	Liquo'ris Cal'cis	Lime Solution
Li'quor Fer'ri Aceta'tis	Liquo'ris Fer'ri Aceta'tis	Solution of Iron Acetate
Li'quor Fer'ri Tersulpha'tis	Liquo'ris Fer'ri Tersulpha'tis	Solution of Iron Tersulphate
Li'quor Plum'bi Subaceta'tis Dilu'tus	Liquo'ris Plum'bi Subaceta'tis Dilu'ti	Diluted Solution of Lead Subacetate
Li'quor Sodæ Chlora'tæ	Liquo'ris So'dæ Chlora'tæ	Solution of Chlorinated Soda
Li'quor So'dii Silica'tis	Liquo'ris So'dii Silica'tis	Solution of Sodium Silicate
Li'quor Zin'ci Chlo'ridi	Liquo'ris Zin'ci Chlo'ridi	Solution of Zinc Chloride
Mas'sa Copai'bæ	Mas'sæ Copai'bæ	Copaiba Mass
Mas'sa Fer'ri Carbona'tis	Mas'sæ Fer'ri Carbona'tis	Mass of Iron Carbonate
Mas'sa Hydrar'gyri	Mas'sæ Hydrar'gyri	Mercury Mass
Mistu'ra Cre'tæ Compo'sita	Mistu'ræ Cre'tæ Compo'sitæ	Compound Chalk Mixture
Mistu'ra Rhe'i et So'dæ	Mistu'ræ Rhe'i et So'dæ	Mixture of Rhubarb and Soda
Mucila'go Sas'safras Medul'læ	Mucila'ginis Sas'safras Medul'læ	Sassafras Mucilage
Mucila'go Ul'mi	Mucila'ginis Ul'mi	Elm Mucilage
Oleoresi'na Aspi'dii	Oleoresi'næ Aspi'dii	Oleoresin of Aspidium
O'leum Phosphora'tum	O'lei Phosphora'ti	Phosphorated Oil
O'pii Pul'vis	O'pii Pul'veris	Powdered Opium
O'pium Deodora'tum	O'pii Deodora'ti	Deodorized Opium
Pi'lulæ A'loes	Pilula'rum A'loes	Aloes Pills
Pi'lulæ A'loes et Fer'ri	Pilula'rum A'loes et Fer'ri	Pills of Aloes and Iron
Pi'lulæ Antimo'ni Compo'sitæ	Pilula'rum Antimo'ni Composita'rum	Compound Antimony Pills
Pi'lulæ Cathar'ticæ Vegeta'biles	Pilula'rum Cathartica'rum Vegetabi'lium	Vegetable Cathartic Pills
Pul'vis Antimonia'lis	Pul'veris Antimonia'lis	Antimonial Powder
Pul'vis Aroma'ticus	Pul'veris Aroma'tici	Aromatic Powder
Pul'vis Cre'tæ Compo'situs	Pul'veris Cre'tæ Compo'siti	Compound Chalk Powder
Pul'vis Efferves'cens	Pul'veris Effervescen'tis	Seidlitz Powder

Compo'situs	Compo'siti	
Pul'vis Ipecacuan'hæ et O'pii	Pul'veris Ipecacuan'hæ et O'pii	Dovers Powder
Resi'na Scammo'nii	Resi'næ Scammo'nii	Scammony Resin
Spi'itus Ae'theris	Spi'ritus Ae'theris	Spirit of Ether
Spi'ritus Ae'theris Compo'situs	Spi'ritus Ae'theris Compo'siti	Compound Spirit of Ether
Spi'ritus Auran'tii	Spi'ritus Auran'tii	Orange Spirit
Spi'ritus Myr'ciæ	Spi'ritus Myr'ciæ	Bay Rum
Supposito'ria Glyceri'ni	Suppositorio'rum Glyceri'ni	Glycerin Suppositories
Syru'pus	Syru'pi	Syrup
Syru'pus Aca'ciæ	Syru'pi Aca'ciæ	Acacia Syrup
Syru'pus A'cidi Ci'trici	Syru'pi A'cidi Ci'trici	Syrup of Citric Acid
Syru'pus Fer'ri Io'didi	Syru'pi Fer'ri Io'didi	Syrup of Iron Iodide
Syru'pus Hypophosphi'tum	Syru'pi Hypophosphi'tum	Syrup of Hypophosphites
Syru'pus Pi'cis Li'quidæ	Syru'pi Pi'cis Li'quidæ	Tar Syrup
Syru'pus Rhe'i	Syru'pi Rhe'i	Rhubarb Syrup
Syru'pus Rhe'i Aroma'ticus	Syru'pi Rhe'i Aroma'tici	Aromatic Rhubarb Syrup
Syru'pus Toluta'nus	Syru'pi Toluta'ni	Tolu Syrup
Syru'pus Zingi'beris	Syru'pi Zingi'beris	Ginger Syrup
Tinctu'ra Aconi'ti	Tinctu'ræ Aconi'ti	Aconite Tincture
Tinctu'ra A'loes	Tinctu'ræ A'loes	Aloes Tincture
Tinctu'ra A'loes et Myr'rhæ	Tinctu'ræ A'loes et Myr'rhæ	Tincture of Aloes and Myrrh
Tinctu'ra Arni'cæ Flo'rum	Tinctu'ræ Arni'cæ Flo'rum	Tincture of Arnica Flowers
Tinctu'ra Auran'tii Ama'ri	Tinctu'ræ Auran'tii Ama'ri	Tincture of Bitter Orange
Tinctu'ra Ki'no	Tinctu'ræ Ki'no	Kino Tincture
Tinctu'ra O'pii Camphora'ta	Tinctu'ræ O'pii Camphora'tæ	Camphorated Tincture of Opium
Tinctu'ra Valeria'næ Ammonia'ta	Tinctu'ræ Valeria'næ Ammonia'tæ	Ammoniated Tincture of Valerian
Tinctu'ra Vanil'læ	Tinctu'ræ Vanil'læ	Vanilla Tincture
Tritura'tio Morphi'næ	Trituratio'nis Morphi'næ	Morphine Trituration
Trochis'ci Cre'tæ	Trochisco'rum Cre'tæ	Chalk Troches
Trochis'ci Men'thæ Piperi'tæ	Trochisco'rum Menthæ Piperi'tæ	Peppermint Troches
Unguen'tum A'quæ Ro'sæ	Unguen'ti A'quæ Ro'sæ	Rose Water Ointment
Unguen'tum Dia'chylon	Unguen'ti Dia'chylon	Diachylon Ointment
Unguen'tum Hydrar'gyri Ammonia'ti	Unguen'ti Hydrar'gyri Ammonia'ti	Ammoniated Mercury Ointment
Unguen'tum Io'di	Unguen'ti Io'di	Iodine Ointment
Unguen'tum Potas'sii Iodidi	Ungueu'ti Potas'sii Io'didi	Potassium Iodide Oinment
Unguen'tum Veratri'næ	Unguen'ti Veratri'næ	Veratrine Ointment
Vi'num Fer'ri Ama'rum	Vi'ni Fer'ri Ama'ri	Bitter Iron Wine
Vi'num Fer'ri Citra'tis	Vi'ni Fer'ri Citra'tis	Wine of Iron Citrate
Vi'num Ipecacuan'hæ	Vi'ni Ipecauan'hæ	Ipecac Wine

1597. Latinic Adjectives Employed in Pharmaceutical Nomenclature and Technical Terminology.

Latin.			English.
Masculine Form.	*Feminine.*	*Neuter.*	
Anima'lis	Anima'lis	Anima'le	Animal
Vegeta'bilis	Vegeta'bilis	Vegeta'bile	Vegetable
Minera'lis	Minera'lis	Minera'le	Mineral
Officina'lis	Officina'lis	Officina'le	Officinal
Sim'plex	Sim'plex	Sim'plex	Simple
Compo'situs	Compo'sita	Compo'situm	Compound
In'teger	In'tegra	In'tegrum	Whole
Inci'sus	Inci'sa	Inci'sum	Cut
Conci'sus	Conci'sa	Conci'sum	Cut
Contu'sus	Contu'sa	Contu'sum	Contused
Ra'sus	Ra'sa	Ra'sum	Rasped
Pulvera'tus	Pulvera'ta	Pulvera'tum	Powdered
Gros'sus	Gros'sa	Gros'sum	Coarse
Cras'sus	Cras'sa	Cras'sum	Coarse
Sub'tilis	Sub'tilis	Sub'tile	Fine
Subtilis'simus	Subtilis'sima	Subtilis'simum	Finest
Du'rus	Du'ra	Du'rum	Hard
Mol'lis	Mol'lis	Mol'le	Soft
Flex'ilis	Flex'ilis	Flex'ile	Flexible
So'lidus	So'lida	So'lidum	Solid
Flu'idus	Flu'ida	Flu'idum	Fluid
Li'quidus	Li'quida	Li'quidum	Liquid
Fu'sus	Fu'sa	Fu'sum	Fused
Fix'us	Fix'a	Fix'um	Fixed
Vola'tilis	Vola'tilis	Vola'tile	Volatile
Pondero'sus	Pondero'sa	Pondero'sum	Heavy
Le'vis	Le'vis	Le've	Light
Solu'bilis	Solu'bilis	Solu'bile	Soluble
Re'cens	Re'cens	Re'cens	Fresh, Recent
Sic'cus	Sic'ca	Sic'cum	Dry
Desicca'tus	Desicca'ta	Desicca'tum	Dried, Desicated
Hu'midus	Hu'mida	Hu'midum	Humid, Moist
Exsicca'tus	Exsicca'ta	Exsicca'tum	Dried, Exsiccated
Al'bus	Al'ba	Al'bum	White
Can'didus	Can'dida	Can'didum	White, Clear
Lu'teus	Lu'tea	Lu'teum	Yellow
Fla'vus	Fla'va	Fla'vum	Yellow
Citri'nus	Citri'na	Citri'num	Yellow
Aure'us	Aure'a	Aure'um	Golden

Aura'tus	Aura'ta	Aura'tum	Golden
Auranti'acus	Auranti'aca	Auranti'acum	Orange Yellow
Ful'vus	Ful'va	Ful'vum	Tawney
Cine'reus	Cine'rea	Cine'reum	Gray
Fus'cus	Fus'ca	Fus'cum	Brown
Ru'ber	Ru'bra	Ru'brum	Red
Cœru'leus	Cœru'lea	Cœru'leum	Blue
Vi'ridis	Vi'ridis	Vi'ride	Green
Ni'ger	Ni'gra	Ni'grum	Black
Decolora'tus	Decolora'ta	Decolora'tum	Decolorized
Ama'rus	Ama'ra	Ama'rum	Bitter
Dul'cis	Dul'cis	Dul'ce	Sweet
Aroma'ticus	Aroma'tica	Aroma'ticum	Aromatic
Odora'tus	Odora'ta	Odora'tum	Odorized
Deodora'tus	Deodora'ta	Deodora'tum	Deodorized
Absolu'tus	Absolu'ta	Absolu'tum	Absolute
Concentra'tus	Concentra'ta	Concentra'tum	Concentrated
For'tis	For'tis	For'te	Strong
For'tior	For'tior	For'tius	Stronger
Dilu'tus	Dilu'ta	Dilu'tum	Dilute, Diluted
Te'nuis	Te'nuis	Te'nue	Thin, Weak
Inspissa'tus	Inspissa'ta	Inspissa'tum	Inspissated
Spis'sus	Spis'sa	Spis'sum	Thick, Firm
Bo'nus	Bo'na	Bo'num	Good
Op'timus	Op'tima	Op'timum	Best
Ve'rus	Ve'ra	Ve'rum	True
Commu'nis	Commu'nis	Commu'ne	Common
Cru'dus	Cru'da	Cru'dum	Crude
Vena'lis	Vena'lis	Vena'le	Crude
Pu'rus	Pu'ra	Pu'rum	Pure
Impu'rus	Impu'ra	Impu'rum	Impure
Depura'tus	Depura'ta	Depura'tum	Purified
Purifica'tus	Purifica'ta	Purifica'tum	Purified
Lo'tus	Lo'ta	Lo'tum	Washed
Cla'rus	Cla'ra	Cla'rum	Clear
Lim'pidus	Lim'pida	Lim'pidum	Limpid
Tur'bidus	Tur'bida	Tur'bidum	Turbid
Clarifica'tus	Clarifica'ta	Clarifica'tum	Clarified
Cola'tus	Cola'ta	Cola'tum	Strained
Filtra'tus	Filtra'ta	Filtra'tum	Filtered
Despuma'tus	Despuma'ta	Despuma'tum	Skimmed
Expres'sus	Expres'sa	Expres'sum	Expressed
Para'tus	Para'ta	Para'tum	Made
Præpara'tus	Præpara'ta	Præpara'tum	Prepared
Leviga'tus	Leviga'ta	Leviga'tum	Levigated

Tri'tus	Tri'ta	Tri'tum	Rubbed
Contri'tus	Contri'tæ	Contri'ta	Triturated together
Turbida'tus	Turbida'ta	Turbida'tum	Turbidated
Granula'tus	Granula'ta	Granula'tum	Granulated
Crystallisa'tus	Crystallisa'ta	Crystallisa'tum	Crystallized
Sublima'tus	Sublima'ta	Sublima'tum	Sublimed
Destilla'tus	Destilla'ta	Destilla'tum	Distilled
Rectifica'tus	Rectifica'ta	Rectifica'tum	Rectified
Lixivia'tus	Lixivia'ta	Lixivia'tum	Lixiviated
Dialysa'tus	Dialysa'ta	Dialysa'tum	Dialysed
Solu'tus	Solu'ta	Solu'tum	Dissolved
Mix'tus	Mix'ta	Mix'tum	Mixed
Commix'ti	Commix'tæ	Commix'ta	Mixed together
Conquassa'tus	Conquassa'ta	Conquassa'tum	Shaken together

Efferves'cens	Efferves'cens	Efferves'cens	Effervescent
Deliques'cens	Deliques'cens	Deliques'cens	Deliquescent

Corrosi'vus	Corrosi'va	Corrosi'vum	Corrosive
Mi'tis	Mi'tis	Mi te	Mild

Glacia'lis	Glacia'lis	Glacia'le	Glacial

Aquo'sus	Aquo'sa	Aquo'sum	Aqueous
Alcoho'licus	Alcoho'lica	Alcoho'licum	Alcoholic
Spirituo'sus	Spirituo'sa	Spirituo'sum	Spirituous
Æthe'reus	Æthe'rea	Æthe'reum	Ethereal
Æthe'ricus	Æthe'rica	Æthe'ricum	Etheric
Oleo'sus	Oleo'sa	Oleo'sum	Oleous. Oily
Vino'sus	Vino'sa	Vino'sum	Vinous

Fer'vidus	Fer'vida	Fer'vidum	Hot
Fer'vens	Fer'vens	Ferven's	Hot
Ebul'liens	Ebul'liens	Ebul'liens	Boiling
Bul'liens	Bul'liens	Bul'liens	Boiling
Ca'lidus	Ca'lida	Ca'lidum	Warm
Te'pidus	Te'pida	Te'pidum	Tepid
Fri'gidus	Fri'gida	Fri'gidum	Cold

Fonta'nus	Fonta'na	Fonta'num	From a Spring
Fluvia'lis	Fluvia'lis	Fluvia'le	From river or lake
Pluvia'lis	Pluvia'lis	Pluvia'le	From rain
Niva'lis	Niva'lis	Niva'le	From snow

Mag'nus	Mag'na	Mag'num	Large
Par'vus	Par'va	Par'vum	Small
Lon'gus	Lon'ga	Lon'gum	Long
Bre'vis	Bre'vis	Bre've	Short
Am'plus	Am'pla	Am'plum	Full
Mi'nor	Mi'nor	Mi'nor	Less

Sin'gulus	Sin'gula	Sin'gulum	Single
Du'plex	Du'plex	Du'plex	Double
Tri'plex	Tri'plex	Tri'plex	Triple
Dimi'dius	Dimi'dia	Dimi'dium	One-half
Æqua'lis	Æqua'lis	Æqua'le	Equal
A'cidus	A'cida	A'cidum	Acid
Alkali'nus	Alkali'na	Alkali'num	Alkaline
Caus'ticus	Caus'tica	Caus'ticum	Caustic
Neutra'lis	Neutra'lis	Neutra'le	Neutral
Ba'sicus	Ba'sica	Ba'sicum	Basic
Reduc'tus	Reduc'ta	Reduc'tum	Reduced
Oxida'tus	Oxida'ta	Oxida'tum	Oxidized
Calcina'tus	Calcina'ta	Calcina'tum	Calcined
Us'tus	Us'ta	Us'tum	Burnt
Hydra'tus	Hydra'ta	Hydra'tum	Hydrated
Hydro'sus	Hydro'sa	Hydro'sum	Hydrous
Anhydro'sus	Anhydro'sa	Anhydro'sum	Anhydrous
Chlora'tus	Chlora'ta	Chlora'tum	Chlorated
Ioda'tus	Ioda'ta	Ioda'tum	Iodated
Sulphura'tus	Sulphura'ta	Sulphura'tum	Sulphurated
Phosphora'tus	Phosphora'ta	Phosphora'tum	Phosphorated
Monobroma'tus	Monobroma'ta	Monobroma'tum	Monobromated
Arse'nicus	Arse'nica	Arse'nicum	Arsenic
Bo'ricus	Bo'rica	Bo'ricum	Boric
Carbo'nicus	Carbo'nica	Carbo'nicum	Carbonic
Chlo'ricus	Chlo'rica	Chlo'ricum	Chloric
Chro'micus	Chro'mica	Chro'micum	Chromic
Ni'tricus	Ni'trica	Ni'tricum	Nitric
Phospho'ricus	Phospho'rica	Phospho'ricum	Phosphoric
Sulphu'ricus	Sulphu'rica	Sulphu'ricum	Sulphuric
Hydrio'dicus	Hydrio'dica	Hydrio'dicum	Hydriodic
Hydrobro'micus	Hydrobro'mica	Hydrobro'micum	Hydrobromic
Hydrochlo'ricus	Hydrochlo'rica	Hydrochlo'ricum	Hydrochloric
Hydrocya'nicus	Hydrocya'nica	Hydrocya'nicum	Hydrocyanic
Ace'ticus	Ace'tica	Ace'ticum	Acetic
Benzo'icus	Benzo'ica	Benzo'icum	Benzoic
Carbo'licus	Carbo'lica	Carbo'licum	Carbolic
Ci'tricus	Ci'trica	Ci'tricum	Citric
Gal'licus	Gal'lica	Gal'licum	Gallic
Ole'icus	Ole'ica	Ole'icum	Oleic
Oxa'licus	Oxa'lica	Oxa'licum	Oxalic
Salicy'licus	Salicy'lica	Salicy'licum	Salicylic
Tan'nicus	Tan'nica	Tan'nicum	Tannic
Tarta'ricus	Tarta'rica	Tarta'ricum	Tartaric

Argen'ticus	Argen'tica	Argen'ticum	Argentic
Cal'cicus	Cal'cica	Cal'cicum	Calcic
Fer'ricus	Fer'rica	Fer'ricum	Ferric
Hydrargy'ricus	Hydrargy'rica	Hydrargy'ricum	Mercuric
Plum'bicus	Plum'bica	Plum'bicum	Plumbic
Nitro'sus	Nitro'sa	Nitro'sum	Nitrous
Sulphuro'sus	Sulphuro'sa	Sulphuro'sum	Sulphurous
Hypophosphoro'sus	Hypophosphoro'sa	Hypophosphoro'sum	Hypophosphorous
Hydro'sus	Hydro'sa	Hydro'sum	Hydrous
Arseno'sus	Arseno'sa	Arseno'sum	Arsenous
Antimono'sus	Antimono'sa	Antimono'sum	Antimonous
Ferro'sus	Ferro'sa	Ferro'sum	Ferrous
Mangano'sus	Mangano'sa	Mangano'sum	Manganous
Hydrargyro'sus	Hydrargyro'sa	Hydrargyro'sum	Mercurous
Antimonia'lis	Antimonia'lis	Antimonia'le	Antimonial
Arsenica'lis	Arsenica'lis	Arsenica'le	Arsenical
Mercuria'lis	Mercuria'lis	Mercuria'le	Mercurial
Peruvia'nus	Peruvia'na	Peruvia'num	Peruvian
Toluta'nus	Toluta'na	Toluta'num	Tolutan
America'nus	America'na	America'num	American
Canaden'sis	Canaden'sis	Canaden'se	Canadian

1598. As the majority of the latinic pharmaceutical titles consist of more than one word, and as one of the words employed in the construction of a compound title is nearly always used in the genitive case, and as the adjectives used are governed, as to number, gender and case, by their respective substantives, it is necessary that the genders, forms and declensions of these words shall be known in order that the latinic titles may be intelligently constructed, used and interpreted.

This may be readily seen from a few examples:

1. The latinic title of "rhubarb" is *Rheum*; the latinic title of "syrup" is *Syrupus*; hence the latinic title for "syrup of rhubarb" must be *Syrupus Rhei*, as the genitive of Rheum is Rhei.

2. The latin for "aromatic" is *Aromaticus* in the masculine gender; but for the feminine gender it becomes *Aromatica*, and in the neuter *Aromaticum*. The latinic title for "plaster" is *Emplastrum* which is neuter; hence the latinic title for "aromatic plaster" would be *Emplastrum Aromaticum*. The latinic title

for "tincture being *Tinctura* which is feminine, the title for "aromatic tincture" must be *Tinctura Aromatica.* But the title for "aromatic syrup of rhubarb" is *Syrupus Rhei Aromaticus* because the word *Syrupus* is masculine.

3.   The latinic word for "pill" is *Pilula*, which is feminine; the plural is *Pilulæ.* The latin of "cathartic" is, in the masculine, *Catharicus*, feminine *Carthartica*, and in the neuter *Catharticum;* in the plural we have *Cathartici*, masculine, *Catharticæ*, feminine, and *Cathartica*, neuter. The latinic titles for "infusion" and for "bolus" are respectively, *Infusum* and *Bolus* with the plurals *Infusa* and *Boli.* Hence we should have: *Bolus Catharticus, Pilula Cathartica, Infusum Catharticum, Boli Cathartici, Pilulæ Catharticæ,* and *Infusa Cathartica.*

4.   In all prescriptions and other formulas where a certain quantity of each article is ordered, the entire title of each article named must, of course, be in the genitive, as it is understood that the formula is introduced by the words "Take of." Thus a prescription ordering twelve compound cathartic pills would read:—

℞ Pilularum Catharticarum Compositarum, No. XII.

We shall now try to give a few simple guides by which the student may be able to determine the gender and declension of some of the words employed.

1599. The latinic nouns ending in *a* or *e* are *feminine* and follow the *first declension.*

Certain words of Greek origin, though having the ending *a* in the nominative singular, follow the third declension, having the case ending —*atis* in the genitive, as: aspidosperma, physostigma, theobroma, rhizoma, stigma, enema, gargarisma, cataplasma. It will be seen that the nominative ending of all these Greek words is –*ma.*

The nouns ending in *us* or *os* are *masculine* and follow the *second declension,* except that the masculine words spiritus, fructus and haustus follow the fourth declension, the words

alnus, juniperus, prunus, rhamnus, sambucus and ulmus which follow the second declension are feminine, the feminine nouns cornus, ficus and quercus follow the fourth declension, and the feminine word rhus has the genitive rhois.

The nouns ending in *um* and *on* are *neuter* and follow the *second declension*, except that limon and erigeron follow the third declension.

The nouns following the third declension have a great variety of endings in the nominative singular and these endings do not generally indicate the gender. It is therefore necessary to find the gender of each word of the third declension. The nouns ending in —*as* and —*is* enumerated in paragraphs 1582 and 1583 are treated as of the masculine gender.

In several of the lists of titles given in the foregoing pages the genders have been marked by the letters m. for masculine, f. for feminine, and n. for neuter. In all cases where the gender is indicated by the ending of the nominative singular, it was not deemed necessary to indicate it in any other manner.

1600. There are five declensions in Latin. They are characterized by the terminations given to the genitive singular, as follows:

Declension.	*Termination of the genitive singular.*
1	æ
2	i
3	is
4	us
5	ei

The endings of the nominatives of the words of each declension vary greatly, and nouns with the same ending are often differently declined.

Of the specific names of particular substances, as the names of metals and other elements, particular oxides, salts, acids,

alkaloids, and any other specified drug, the plurals are of course not used. There can be but one iron, gold, mercuric iodide, morphine, squill, etc. But of the names of plant parts, classes of chemical compounds, preparations, etc., the plurals are used, for we have several kinds of roots, seeds, tinctures, pills, ointments, oxides, acids, etc.

1601. First declension.—Nouns of the first declension end in **a** or **e** in the nominative singular, and are of the feminine gender. The only nouns ending in *e*, which are of interest to pharmacists, are aloe, mastiche and statice.

The endings of nominatives and genitives, singular and plural, are:

	Singular.	*Plural.*
Nom.	**a** or **e**	**æ**
Gen.	**æ** or **es**	**arum**

Thus we have:

Singular.		*Plural.*	
Nom.	*Gen.*	*Nom.*	*Gen.*
Herba	Herbæ	Herbæ	Herb**arum**
Pilula	Pilulæ	Pilulæ	Pilul**arum**
Tinctura	Tincturæ	Tincturæ	Tinctur**arum**
Cera	Ceræ	not used	
Rosa	Rosæ	Rosæ	Ros**arum**
Soda	Sodæ	not used	
Aloe	Aloes	" "	

Examples of nouns of the first declension are: Acacia, aqua, cera, charta, herba, manna, massa, mistura, pasta, pilula, resina, rosa, tinctura, aloe, mastiche.

1602. Second declension.—Nouns of the second declension ending in **us** or **os** are masculine; those ending in **um** or **on** are neuter. But alnus, juniperus, prunus, sambucus and ulmus, all of which follow this declension, are feminine.

The endings of the nominatives and genitives, singular and plural, are:

	Singular.		*Plural.*	
	Masc.	*Neuter.*	*Masc.*	*Neuter.*
Nom........	**us** or **os**	**um** or **on**	i	a
Gen........		i		**orum**

Thus we have:

Singular.		*Plural.*	
Nom.	*Gen.*	*Nom.*	*Gen.*
Bolus	Boli	Boli	Bol**orum**
Syrup**us**	Syrupi	Syrupi	Syrup**orum**
Acid**um**	Acidi	Acid**a**	Acid**orum**
Vin**um**	Vini	Vin**a**	Vin**orum**
Prin**os**	Prini	not used	
Diospyr**os**	Diospyri	"	
Eriodicty**on**	Eriodictyi	"	
Erythroxyl**on**	Erythroxyli	"	

Examples of nouns of the second declension: Bulbus, trochiscus, caryophyllus, crocus, humulus, hyoscyamus, rubus, ceratum, extractum, folium, lignum, oxidum, chloridum, chlorum, iodum, glycerinum, oleum, rheum, toxicodendron, hæmatoxylon.

1603. Third declension.—Nouns of the third declension have many different terminations in the nominative singular, and they may be of any gender. Among the common endings of words of this declension are as, is, or, er, io.

The ending of the genitive singular is **is,** and in the plural the nominative ends in **es,** but occasionally in **ata,** and the genitive in **um** or sometimes **ium.**

The following examples are probably sufficient to show the general modes of changing the case-endings:

Singular.		*Plural.*	
Nom.	*Gen.*	*Nom.*	*Gen.*
Par**s**	Part**is**	Part**es**	Part**ium**
Citra**s**	Citr**atis**	Citr**ates**	Citr**atum**
Aceta**s**	Acet**atis**	Acet**ates**	Acet**atum**

Sulphas	Sulphatis	Sulphates	Sulphatum
Sulphis	Sulphitis	Sulphites	Sulphitum
Nitris	Nitritis	Nitrites	Nitritum
Arsenas	Arsenatis	Arsenates	Arsenatum
Arsenis	Arsenitis	Arsenites	Arsenitum
Pulvis	Pulveris	Pulveres	Pulverum
Liquor	Liquoris	Liquores	Liquorum

Singular.		*Plural.*	
Nom.	*Gen.*	*Nom.*	*Gen.*
Lotio	Lotionis	Lotiones	Lotionum
Emulsio	Emulsionis	Emulsiones	Emulsionum
Mucilago	Mucilaginis	Mucilagines	Mucilaginum
Sapo	Saponis	Sapones	Saponum
Cataplasma	Cataplasmatis	Cataplasmata	Cataplasmatum
Tuber	Tuberis	Tubera	Tuberum
Radix	Radicis	Radices	Radicium
Cortex	Corticis	Cortices	Corticium
Flos	Floris	Flores	Florum
Semen	Seminis	Semina	Seminum
Summitas	Summitatis	Summitates	Summitatum
Stigma	Stigmatis	Stigmata	Stigmatum
Rhizoma	Rhizomatis	Rhizomata	Rhizomatum
Stipes	Stipitis	Stipites	Stipitum
Borax	Boracis	not used	
Calx	Calcis	"	
Rumex	Rumicis	"	
Pix	Picis	"	
Macis	Macidis	"	
Berberis	Berberidis	"	
Adeps	Adipis	"	
Asclepias	Asclepiadis	"	
Juglans	Juglandis	"	
Piper	Piperis	"	
Zingiber	Zingiberis	"	

Mel	Mellis	not used
Mas	Maris	"
Lac	Lactis	"
Digitalis	Digitalis	"
Alumen	Aluminis	"
Rhus	Rhois	"
Erigeron	Erigerontis	"

1604. Fourth Declension.—The only nouns of the fourth declension which occur commonly in pharmaceutical nomenclature are spiritus, ficus, fructus, cornus, haustus and quercus. They are declined as follows:

Singular.		*Plural.*	
Nom.	*Gen.*	*Nom.*	*Gen.*
Spiritus	Spiritus	Spiritus	Spirituum
Ficus	Ficus	Ficus	Ficuum
Fructus	Fructus	Fructus	Fructuum
Haustus	Haustus	Haustus	Haustuum
Cornus	Cornus	not used	
Quercus	Quercus	"	

1605. Fifth Declension.—Probably the only word in pharmaceutical terminology which comes under the fifth declension is the title *species*, which is only used in the plural. It is applied to mixtures of cut, crushed or ground drugs intended to be used for teas, decoctions, bitters, etc. The nominative is species, and the genitive specierum.

1606. As there are but six words of the fourth and one of the fifth declension, and as the words ending in *a* or *e* follow the first declension and those ending in *us*, *os*, *um* and *on* the second declension, it follows that other words are of the third declension.

1607. Adjectives.—The adjectives commonly used in pharmaceutical nomenclature are not many. They are declined in accordance with the first declension when of the feminine form ending in *a*, the second declension when of the masculine

form ending in *us*, or the neuter form ending in *um*, they follow the third declension when of the masculine form and ending in *er* or *is*, of the feminine form and ending in *is*, and of the neuter form and ending in *e*.

Certain adjectives ending with the letter s, or x, have the same ending for all three genders in each case, as simplex, simplicis, simplices, simplicia, simpliciorum, etc.

In the comparative degree the adjectives have the endings *–ior* in the masculine and feminine forms, and *–ius* in the neuter; and in the superlative degree the ending *–issimus* for the masculine, *–issima* for the feminine, and *–issimum* for the neuter form.

The following examples are sufficient by way of illustrations—

Singular	Nom.	Purus (Pure)	Pura	Purum
	Gen.	Puri	Puræ	Puri
Plural	Nom.	Puri	Puræ	Pura
	Gen.	Purorum	Purarum	Purorum

Singular	Nom.	Niger (Black)	Nigra	Nigrum
	Gen.	Nigri	Nigræ	Nigri
Plural	Nom.	Nigri	Nigræ	Nigra
	Gen.	Nigrorum	Nigrarum	Nigrogrum

Singular	Nom.	Mitis (Mild)	Mitis	Mite
	Gen.	Mitis	Mitis	Mitis
Plural	Nom.	Mites	Mites	Mites
	Gen.	Mitium	Mitium	Mitium

Singular	Nom.	Acer (Sharp)	Acris	Acre
	Gen.	Acris	Acris	Acris
Plural	Nom.	Acres	Acres	Acres
	Gen.	Acrium	Acrium	Acrium

Singular	Nom.	Simplex	Simplex	Simplex
	Gen.	Simplicis	Simplicis	Simplicis
Plural	Nom.	Simplices	Simplices	Simplicia
	Gen.	Simplicium	Simplicium	Simplicum

Singular	Nom.	Recens	Recens	Recens
	Gen.	Recentis	Recentis	Recentis
Plural	Nom.	Recentes	Recentes	Recentia
	Gen.	Recentium	Recentium	Recentium

The great majority of the latinic adjectives used in pharmaceutical nomenclature are declined as purus or as mitis.

1608. Numerals.—The Roman notation is commonly used in prescriptions. The signs are:

I	1	XI	11	XL	40
II	2	XII	12	L	50
III	3	XIII	13	LX	60
IV	4	XIV	14	XC	90
V	5	XV	15	C	100
VI	6	XVI	16	CX	110
VII	7	XVII	17	CC	200
VIII	8	XVIII	18	D	500
IX	9	XIX	19	DC	600
X	10	XX	20	M	1,000

The Roman cardinals and ordinals are as follows:

Cardinals		*Ordinals*	
Unus, una, unum	1	Primus	First
Duo, duæ, duo	2	Secundus	Second
Tres, tres, tria	3	Tertius	Third
Quatuor	4	Quartus	4th
Quinque	5	Quintus	5th
Sex	6	Sextus	6th

Cardinals.		*Ordinals.*	
Septem	7	Septimus	7th
Octo	8	Octavus	8th
Novem	9	Nonus	9th
Decem	10	Decimus	10th
Undecim	11	Undecimus	11th
Duodecim	12	Duodecimus	12th
Tredecim	13	Tertius decimus	13th
Quatuordecim	14	Quartus decimus	14th
Quindecim	15	Quintus decimus	15th
Sexdecim	16	Sextus decimus	16th
Septendecim	17	Septimus decimus	17th
Duodeviginti	18	Duodevicesimus	18th
Undeviginti	19	Undevicesimus	19th
Viginti	20	Vicesimus	20th
Viginti unus	21	Vicesimus primus	21st
Viginti duo	22	Vicesimus secundus	22d
Triginta	30	Tricesimus	30th
Quadraginta	40	Quadragesimus	40th
Quinquaginta	50	Quinquagesimus	50th
Sexaginta	60	Sexagesimus	60th
Septuaginta	70	Septuagesimus	70th
Octoginta	80	Octogesimus	80th
Nonaginta	90	Nonagesimus	90th
Centum	100	Centesimus	100th
Ducenti	200	Ducentesimus	200th
Trecenti	300	Trecentesimus	300th
Quadrigenti	400	Quadringentesimus	400th
Quingenti	500	Quingentesimus	500th
Sexcenti	600	Sexcentesimus	600th
Septingenti	700	Septingentesimus	700th
Octingenti	800	Octingentesimus	800th
Nongenti	900	Nongentesimus	900th
Mille	000	Millesimus	1,000th

Bis means twice.
Ter and *Tris* mean thrice.
Simplex means simple.
Duplex means double.
Triplex means triple.
Quadruplex means quadruple.

The ordinals are all declinable like adjectives, thus:

| Primus | prima | primum |
| Secundus | secunda | secundum |

The cardinals are indeclinable, except *unus*, *duo* and *tres*, which are declined as follows:

	Masc.	*Fem.*	*Neuter.*
Nom.	unus	una	unum
Gen.	unius	unius	unius
Accus.	unum	unam	unum
Nom.	duo	duæ	duo
Gen.	duorum	duarum	duorum
Accus.	duos	duas	duo
Nom.	tres	tres	tria
Gen.	trium	trium	trium
Accus.	tres	tres	tria

CHAPTER XC.

WEIGHTS AND MEASURES.

The weights and measures employed in medicine and pharmacy throughout the world, except in the English speaking countries, are those of the so-called " Metric System."

The Metric System is universally employed in chemistry.

For *all* purposes that system is now compulsory in every civilized country except Great Britain, Russia and the United States of America. In Russia its use is compulsory in medicine and pharmacy. In England and America its use for any or all purposes is specially authorized by law.

When the new British Pharmacopœia, now in course of preparation (January, 1896) shall have been published there will be no pharmacopœia in the world that does not employ the measures of the decimal system based upon the METER.

It is, therefore, the duty of every pharmacist to know the Metric System well so as to be able to use it safely, correctly, and readily.

Physicians now practicing in England and America may not use the Metric System in writing their prescriptions; but they will not be able to the fullest extent to avail themselves of the advancement made in practical medication as reported in current medical literature, unless they are familiar with the universal system of weights and measures. Coming generations of physicians will be obliged to use it unless they are willing to deliberately shut themselves out from the most direct and easy language by which communication is effected

between scientific medical men the world over in all matters
requiring the expression of quantities and doses of medicinal
agents. Medical schools of any pretension to efficiency will
necessarily teach their students the Metric System itself and
its use, not only in prescription writing but for all other pur-
poses for which the employments of units of weight or of
volume are necessary, and the teachers in all such schools will
no longer use any terms of expression for weights and vol-
umes except those of the only scientific system of metrology
in existence.

The so-called METRIC SYSTEM is a system of weights and
measures devised about one hundred years ago by a number
of the scientific men of the world at that time. It is called
" Metric " because it is founded upon a unit of length called
the METER, represented by a platinum bar kept in the Palace
of the Archives at Paris. That meter bar is known as the
" meter of the archives."

The principal characteristics of the Metric System are these:

1. The unit of length (the *Meter*) is the basis of all the
units of measurement of the whole system—linear measure,
square measure, cubic measure and other measures of capacity,
and the measures of weight.

2. All the units employed bear the simplest possible rela-
tion to each other as well as to the basic linear unit.

3. In all its progressions from lower to higher or from
larger to smaller units the Metric System agrees with our arith-
metical notation, being decimal throughout, which renders
computations and expressions as easy as possible.

4. It is based upon scientific principles as to the standard
of temperature and other conditions affecting the reciprocal
relations of the various kinds of units and the construction and
use of the *actual standards* or prototypes of the primary units
of length and of weight.

The student should at once understand that in order to use

any system of weights and measures intelligently and correctly he must be well drilled in arithmetic; at least, far enough to be able to readily work out problems in fractions and proportion. The use of decimal fractions, and the correct reading and writing of such fractions, should be as familiar to you as your a, b, c, and if that is not the case you should at once remedy this defect.

The Metric System can be mastered without difficulty, and it is, of course, just as easy to use a measuring vessel graduated in metric terms as to use one graduated in fluid ounces and fluid drachms, and as easy to use the balance (commonly called "scales") with metric weights as with pounds, ounces, drachms, scruples and grains.

Every retail drug store should possess complete sets of metric weights and metric "graduates." They are not more costly than other weights and graduates; their possession will render conversions from one system to another unnecessary, and a pharmacist without metric weights and measures and without the knowledge and skill necessary to use them with ease and accuracy would be a poor pharmacist, indeed.

Table of Metric Measures of Length.

1,000 Meters= 1 Kilometer
100 Meters= 1 Hektometer
10 Meters= 1 Dekameter

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1 Meter= 10 Decimeters
1 Meter= 100 Centimeters
1 Meter= 1,000 Millimeters

1 Meter is equal to 39.37 English inches.
25 millimeters= nearly 1 inch.

Table of Metric Measures of Capacity.

1,000 Liters=1 Kiloliter
1 Liter=1,000 Milliliters

1 Liter is equal to about 33.8 U. S. fluidounces.
1 milliliter=16 minims.

The milliliter is commonly called a cubic-centimeter.

Theoretically the liter is 1 cubic-decimeter, or 1,000 cubic-centimeters; but the actual liter is the volume of 1 kilogram of pure water at the temperature of 4°C. weighed *in vacuo*, for liter measures and all graduated measuring vessels and apparatus are made or adjusted by weighing water into them, not by any measuring of their extension.

Table of Metric Measures of Weight.

1000 Grams=1 Kilogram
100 Grams=1 Hektogram
10 Grams=1 Dekagram

———

1 Gram=10 Decigrams
1 Gram=100 Centigrams
1 Gram=1000 Milligrams

1 Gram is equal to 15.43235639 grains.
1 milligram is about equal to 1-64 grain.

———

The only units that *ought to be* used in medicine and pharmacy are the Liter (written L.), the milliliter (written ml.), the Kilogram (written KGm) the Gram (written Gm.) the milligram (written mGm), and the millimeter (written mm.)

It will be seen that the *principal unit* of length is the METER; the *principal unit* of volume is the LITER; and the *principal unit* of weight is the GRAM. The smaller and larger units are obtained by division and multiplication, ten equal units of one kind making one unit of the next larger denomination of the same kind. Thus 10 millimeters make 1 centimeter; 10 centimeters

make 1 decimeter; 10 decimeters make 1 Meter; 10 Meters
make 1 dekameter; 10 dekameters make 1 hektometer; and 10
hektometers make 1 kilometer. Of the measures of capacity
10 milliliters (or cubic-centimeters) make 1 centiliter; 10 cen-
tiliters make 1 deciliter; 10 deciliter make 1 Liter; 10 Liters
make 1 dekaliter; 10 dekaliters make 1 hektoliter; and 10 hek-
toliters make 1 kiloliter. Of the weight units 10 milligrams
make 1 centigram; 10 centigrams make 1 decigram; 10 deci-
grams make 1 Gram; 10 Grams make 1 dekagram; 10 deka-
grams make 1 hektogram; 10 hektograms make 1 kilogram.

The *prefixes* employed are, therefore:—

Milli—which means one one-thousandth part;

Centi—which means one one-hundreth part;

Deci—which means one tenth part;

Deka—which means ten;

Hekto—which means one hundred; and

Kilo—which means one thousand.

Hence one **kilo**gram is one thousand Grams;

one **kilo**meter is one thousand Meters;

one **kilo**liter is one thousand Liters;

one **hekto**meter is one hundred Meters;

one **deka**gram is ten Grams;

one **deci**liter is 0.1 Liter;

one **centi**meter is 0.01 Meter;

one **milli**gram is 0.001 Gram.

But the prefixes *hekto*— and *deka*— are rarely used, and
ought to be discontinued because they are as useless incum-
brances in the Metric System as the mill, dime and eagle are
in American money; the prefix *deci*— is sometimes employed
but as unnecessary as the hekto— and deka—. The three pre-
fixes *kilo*—, *centi*— and *milli*— are much used, and the *kilo*—
and *milli*— are indispensable.

Equivalents.

1 U. S. Fluidounce = *about* 32 Cc.
1 " Fluidrachm = " 4 Cc.
15 " Minims (16.231) = *about* 1 Cc.

———

1 Apothecaries' Ounce (or Troy ounces) = about 32 Gm
1 " Drachm = " 4 Gm
15 " Grains = " 1 Gm

In writing quantities by weight or measure in the Metric System, the common or *Arabic* numerals are used (not the Roman), and the numbers are always placed *before* the signs or abbreviations representing the units. Thus—

Five cubic-centimeters is written 5 Cc.
Fifteen Grams is written 15 Gm.
One and one-half Gram is written 1.500 Gm.
Five hundred milligrams is written 500 mGm.
or it may be written 0.500 Gm.

A comma should *never* be used instead of the period to point off decimal fractions, and it is always most convenient, plain and safe to use such small units that fractions are avoided as far as possible. It is, for instance, much better to write 5 mGm than to write 0.005 Gm. The 0 before the decimal point when there are no whole units should by no means be omitted; it is safer to write 0.05 mGm than to write .05 mGm.

Apothecaries' Fluid Measure.

1 Gallon (C) = 8 pints
1 Pint (O) = 16 fluidounces
1 Fluidounce (f℥) = 8 fluidrachms
1 Fluidrachm (f℥) = 60 minims.

Apothecaries' Weight.

1 Pound (lb) = 12 ounces.
1 Ounce (℥) = 8 drachms, or 480 grains.

1 Drachm (ʒ) = 3 scruples or 60 grains.
1 Scruple (Ɖ) = 20 grains.

In writing quantities in terms of Apothecaries Weights and Measures, *Roman* numerals are used, and the numbers are always placed *after* the signs or terms which represent the units, thus: gr. x; Ɖ j; ʒ vj; ʒiv; ♏xxx; f ʒ ij; fʒ viij, etc.

AVOIRDUPOIS WEIGHT.

The *Commercial weight* in common use in the United States is the Imperial Weight of Great Britain, the units of which are as follows:

The grain (gr.) [This grain is identical in value with the Apothecaries. grain and the grain of Troy Weight.]
The Ounce (oz.), equal to 437½ grains.
The Pound (℔), edual to 16 ounces, or 7,000 grains.

RELATIONS OF WEIGHTS AND MEASURES OF THE SEVERAL SYSTEMS.

Measure.		*Weight.*
1 Cc. of pure water weighs		1 Gm
1 Liter " " "		1 Kilogram
1 Minim (U. S.) of pure water weighs		0.95 grains
1 Fluidrachm " " " "		56.96 "
1 Fluidounce " " " "		455.69 "
96 U. S. fluidounces of pure water weighs 100 avoirdupois ounces.		

Weight.		*Measure.*
1 Gram of pure water measures		1 Cc.
1 Kilogram " " "		1 Liter
1 Grain of pure water measures	1.05 minims	
1 Drachm " " "	63.2 "	
1 Ounce " " "	505.6 "	

RELATIONS OF METRIC UNITS AND THE OLD UNITS.

1 Meter = 39,37 inches
1 Centimeter = about 0.4 inch
1 Millimeter = about 0.04 inch

1 Liter = about 34 U. S. fluid ounces
1 Cc. = about 16 U. S. minims
1 Kilogram = about 35 avoirdupois ounces
1   "   = about 32 apothecaries' ounces
1 Gram   = about 16 grains
1 Milligram = about $\frac{1}{64}$ grain
1 Inch = about 25 millimeters
1 U. S. Fluidounce = about 30 Cc.
1   "   Minim   = about 0.06 Cc.
1 Apothecaries' Ounce = about 32 Gm
1   "   Drachm = about 4 Gm
1   "   Grain = 64 milligrams
1 Avoirdupois Pound = 453.6 Grams
1   Ounce = 28.35   "

IMPERIAL FLUID MEASURE—(GREAT BRITAIN.)

The minim (m), equal to
The Fluidrachm (f ʒ), equal to 60 such minims.
The Fluidounce (f ℥), equal to 8 such fluidrachms, or
        480 minims.
The Pint, equal to 20 such fluidounces.
The Gallon, equal to 8 such pints.
1 Imperial Gallon is the volume of 10 avoirdupois pounds of water at 62° F.
1 Imperial Fluidounce of water weighs 1 avoirdupois ounce.

        The weights and measures in common use for com-
mercial and other purposes in the United States are those
brought to us from England in colonial times. Some of these
were abolished in that country by law of Parliament in 1824
when the Imperial system was established. There has been
no legislation by the Congress of the United States prescribing
or establishing a national system of weights and measures or
fixing the values of the units in common use.

    The United States is the only civilized country in the world
that has no fixed legal standards of weights and measures.

But, the Congress passed a law in 1866 *authorizing* the use of the Metric System. It may, therefore, be truly said that the Metric System is the only system of weights and measures specially legalized in this country. The customary weights and measures (borrowed from England and since in part abolished in that country) are lawful and binding as a matter of "common law," but the standards and values of these customary weights and measures of the United States have not been named or defined by legislation.

The standards used prior to 1892 by the Office of Standard Weights and Measures at Washington, were the so-called "Hassler Standards" based upon a brass bar called the "Troughton scale" supposed to correctly represent the English standard of linear measure, and a copy of an old English Troy Pound, which copy was obtained from the British Goverment to be used for the purpose of regulating the weight of our coin. Captain Hassler determined experimentally the weight of a cubic-inch of water in grains and fixed the value of the liquid gallon (supposed to be 231 cubic-inches) in accordance with that determination.

At the present time, however, the defective Hassler standards have been discarded, and the American National Prototype Standards of the Meter and the Kilogram, made of irido-platinum, received by the United States from the International Bureau of Weights and Measures in 1890, are the actual ultimate standards from which *all* weights and measures employed in this country are derived. Not only the metric weights and measures used in the United States, but also the yard-sticks, inch-rules, bushel and gallon measures, pound weights, and all other measures and weights used in our country, are adjusted, standarded or verified with ultimate reference to our actual metric standards. Thus our country has at last, at the command of the office of Weights and Measures, the scientific and fixed material standards necessary to accurate determin-

ations and comparisons, and the adoption of these standards by that office was a great step forward. It must not be supposed, however, that this action by the office of Standard Weights and Measures has in any manner or degree affected the freedom with which the old customary weights and measures are and may continue to be used; it will simply render the values of those old weights and measures more definite and reliable.

INDEX.

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